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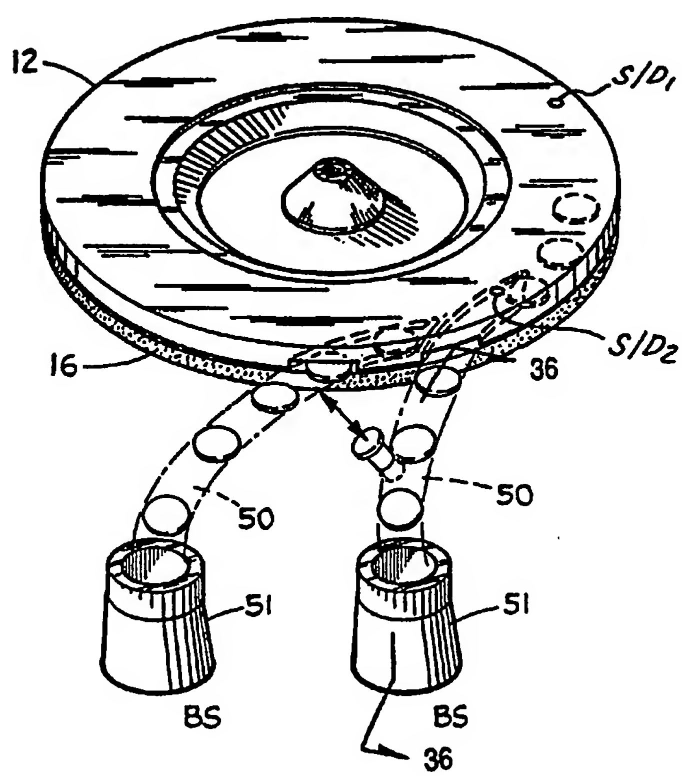
(54) Title: COIN HANDLING SYSTEM WITH SHUNTING MECHANISM

(57) Abstract

A coin sorter for sorting mixed coins by denomination includes a rotatable disc (13), a drive motor (14) rotating the disc, and a stationary sorting head (12) having a lower surface generally parallel to the upper surface of the rotatable disc and spaced slightly therefrom. The lower surface of the sorting head forms a plurality of exit channels (40, 41, 42, 43, 44, 45) for guiding coins of different denominations to different exit locations around the periphery of the disc. Shunting mechanisms (1050) are disposed in one or more of the exit channels or are disposed outside the periphery of the disc adjacent one or more of the exit locations. These shunting mechanism are used to separate coins into two or more batches for the purpose of either discriminating between valid coins and invalid coins or for the purpose of accumulating a predetermined number of coins in one batch and then accumulating additional coins in another batch.



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COIN HANDLING SYSTEM WITH SHUNTING MECHANISM

Cross-Reference To Related Applications

This application is a continuation-in-part of copending U.S. patent application Serial No. 08/149,660, filed November 9, 1993, and entitled "Coin Handling System With Coin Sensor Discriminator", which is in turn a continuation-in-part of copending U.S. patent application Serial No. 08/115,319, filed September 1, 1993, and entitled "Coin Handling System With Controlled Coin Discharge", which is in turn a continuation-in-part of copending U.S. patent application Serial No. 07/951,731, filed September 25, 1992 (allowed on October 1, 1993), and entitled "Coin Handling System," which is in turn a continuation-in-part of copending U.S. patent application Serial No. 07/904,161 filed August 21, 1992 (now issued as U.S. patent number 5,277,651), and entitled "Coin Sorter with Automatic Bag-Switching or Stopping," which in turn is a continuation of U.S. patent application Serial No. 07/524,134 filed May 14, 1990 (now issued as U.S. patent number 5,141,443), and entitled "Coin Sorter With Automatic Bag-Switching Or Stopping."

Field Of The Invention

The present invention relates generally to coin handling systems and, more particularly, to coin handling systems of the type which use a resilient disc rotating beneath a stationary coin-manipulating head.

Summary Of The Invention

An object of the present invention is to provide a coin handling system which uses a shunting mechanism for diverting coins to different receptacles (e.g., coin bags). Coins may be diverted to different receptacles for the purpose of either discriminating between valid coins and invalid coins (e.g., foreign and counterfeit coins) or for the purpose of capturing a predetermined number of coins in one receptacle and then capturing additional coins in another receptacle.

In accordance with the foregoing object, the present invention provides a coin sorter for sorting mixed coins by denomination includes a rotatable disc, a drive motor for rotating the disc, and a stationary sorting head having a lower surface generally parallel to the upper surface of the rotatable disc and spaced slightly therefrom. The lower surface of the sorting head forms a plurality of exit channels for guiding coins of different denominations to different exit locations around the periphery of the disc. Shunting mechanisms are disposed in one or more of the exit channels or are disposed outside the periphery of the disc adjacent one or more of the exit locations. These shunting mechanisms are used to separate coins into

two or more batches.

The above summary of the present invention is not intended to represent each embodiment, or every aspect, of the present invention. This is the purpose of the detailed description which follows.

Brief Description Of The Drawings

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1 is perspective view of a coin counting and sorting system, with portions thereof broken away to show the internal structure;

FIG. 2 is an enlarged bottom plan view of the sorting head or guide plate in the system of FIG. 1;

FIG. 3 is an enlarged section taken generally along line 3-3 in FIG. 2;

FIG. 4 is an enlarged section taken generally along line 4-4 in FIG. 2;

FIG. 5 is an enlarged section taken generally along line 5-5 in FIG. 2;

FIG. 6 is an enlarged section taken generally along line 6-6 in FIG. 2;

FIG. 7 is an enlarged section taken generally along line 7-7 in FIG. 2;

FIG. 8 is an enlarged section taken generally along line 8-8 in FIG. 2;

FIG. 9 is an enlarged section taken generally along line 9-9 in FIG. 2;

FIG. 10 is an enlarged section taken generally along line 10-10 in FIG. 2;

FIG. 11 is an enlarged section taken generally along line 11-11 in FIG. 2;

FIG. 12 is an enlarged section taken generally along line 12-12 in FIG. 2;

FIG. 13 is an enlarged section taken generally along line 13-13 in FIG. 2;

FIG. 14 is an enlarged section taken generally along line 14-14 in FIG. 2, and illustrating a coin in the exit channel with the movable element in that channel in its retracted position;

FIG. 15 is the same section shown in FIG. 14 with the movable element in its advanced position;

FIG. 16 is an enlarged perspective view of a preferred drive system for the rotatable disc in the system of FIG. 1;

FIG. 17 is a perspective view of a portion of the coin sorter of FIG. 1, showing two of the six coin discharge and bagging stations and certain of the components included in those stations;

FIG. 18 is an enlarged section taken generally along line 18-18 in FIG. 17 and showing additional details of one of the coin discharge and bagging station;

FIG. 19 is a block diagram of a microprocessor-based control system for use in the coin counting and sorting system of FIGS. 1-18;

FIGS. 20A and 20B, combined, form a flow chart of a portion of a program for controlling the operation of the microprocessor included in the control system of FIG. 19;

FIG. 21 is a bottom plan view of a further modified sorting head for use in the coin counting and sorting system of FIG. 1;

FIG. 22 is a section taken generally along line 22-22 in FIG. 21;

FIG. 23 is a section taken generally along line 23-23 in FIG. 21;

FIG. 24 is an enlarged plan view of a portion of the sorting head shown in FIG. 21;

FIG. 25 is a section taken generally along line 25-25 in FIG. 24;

FIG. 26 is a section taken generally along line 26-26 in FIG. 24;

FIGS. 27a and 27b form a flow chart of a microprocessor program for controlling the disc drive motor and brake in a coin sorter using the modified sorting head of FIG. 21;

FIGS. 28a and 28b form a flow chart of a "jog sequence" subroutine initiated by the program of FIGS. 27a and 27b;

FIG. 29 is a flow chart of an optional subroutine that can be initiated by the subroutine of FIGS. 28a and 28b;

FIG. 30 is a timing diagram illustrating the operations controlled by the subroutine of FIGS. 28a and 28b;

FIG. 31 is a timing diagram illustrating the operations controlled by the subroutines of FIGS. 28 and 29;

FIGS. 32a and 32b are block diagrams of alternative coin sensor/discriminator circuit arrangements for discriminating valid coins from invalid coins;

FIG. 33 is a perspective view of a coin sorting arrangement including the sensor/discriminator of FIG. 32 and a coin diverter which is controlled in response to the sensor/discriminator;

FIG. 34 is a bottom view of a stationary guide plate shown in the arrangement of FIG. 33;

FIG. 35 is a perspective view of another coin sorting arrangement;

FIG. 36 is a cut-away view of the system shown in FIG. 35, showing an invalid coin being deflected from a coin exit chute;

FIG. 37 is flow chart showing a way to program a controller for sorting and counting coins of multiple denominations in a coin sorting system, such as the one shown in FIG. 34;

FIG. 38 is a bottom plan view of a sorting head including coin sensor/discriminators for use in the coin sorting system of FIG. 1;

FIG. 39 is an enlarged section taken generally along line 39-39 in FIG. 38;

FIG. 40a is an enlarged bottom plan view of an inboard shunting device embodying the present invention;

FIG. 40b is a perspective view of the inboard shunting device in FIG. 40a, showing a rotatable pin in a nondiverting position;

FIG. 40c is a perspective view of the inboard shunting device in FIG. 40a, showing the rotatable pin in a diverting position;

FIG. 41a is an enlarged bottom plan view of an alternative inboard shunting device embodying the present invention;

FIG. 41b is a perspective view of the inboard shunting device in FIG. 41a, showing an extendable pin in a nondiverting position;

FIG. 41c is a perspective view of the inboard shunting device in FIG. 41a, showing the extendable pin in the diverting position;

FIG. 42 is a perspective view of an outboard shunting device embodying the present invention;

FIG. 43 is a section taken generally along line 43-43 in FIG. 42;

FIG. 44 is a section taken generally along line 44-44 in FIG. 42, showing a movable partition in a nondiverting position;

FIG. 45 is the same section illustrated in FIG. 44, showing the movable partition in a diverting position;

FIG. 46 is a perspective view of the outboard shunting device in FIG. 42, further including an external drive system located upstream from the outboard shunting device;

FIG. 47 is a cross-sectional view of an alternative outboard shunting device embodying the present invention, showing a pair of pneumatic pumps diverting coins into a first slot of an exit chute;

FIG. 48 is the same cross-sectional view illustrated in FIG. 47, showing the pair of pneumatic pumps diverting coins into a second slot of the exit chute;

FIG. 49 is the same cross-sectional view illustrated in FIG. 47, further including an external drive system located upstream from the outboard shunting device and showing the pair of pneumatic pumps diverting coins into the first slot of the exit chute;

FIG. 50 is the same cross-sectional view illustrated in FIG. 49, showing the pair of pneumatic pumps diverting coins into the second slot of the exit chute;

FIG. 51 is a perspective view of another alternative outboard shunting device embodying the present invention;

FIG. 52 is a section taken generally along line 52-52 of FIG. 51;

FIG. 53 is a top plan view of the outboard shunting device in FIG. 51, showing a movable partition in a first position;

FIG. 54 is a top plan view of the outboard shunting device in FIG. 51, showing a movable partition in a second position;

FIG. 55 is a perspective view of the outboard shunting device in FIG. 51, further including an external drive system located upstream from the outboard shunting device;

FIGS. 56a and 56b are top plan views of yet another alternative outboard shunting device embodying the present invention; and

FIGS. 57a and 57b are top plan views of a further alternative outboard shunting device embodying the present invention.

While the invention is susceptible to various modifications and alternative forms, certain specific embodiments thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular forms described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

Description Of The Preferred Embodiments

Turning now to the drawings and referring first to FIG. 1, a hopper 10 receives coins of mixed denominations and feeds them through central openings in an annular sorting head or guide plate 12. As the coins pass through these openings, they are deposited on the top surface of a rotatable disc 13. This disc 13 is mounted for rotation on a stub shaft (not shown) and driven by an electric motor 14. The disc 13 comprises a resilient pad 16, preferably made of a resilient rubber or polymeric material, bonded to the top surface of a solid metal disc 17.

As the disc 13 is rotated, the coins deposited on the top surface thereof tend to slide outwardly over the surface of the pad due to centrifugal force. As the coins move outwardly, those coins which are lying flat on the pad enter the gap between the pad surface and the guide plate 12 because the underside of the inner periphery of this plate is spaced above the pad 16 by a distance which is about the same as the thickness of the thickest coin.

As can be seen most clearly in FIG. 2, the outwardly moving coins initially enter an annular recess 20 formed in the underside of the guide plate 12 and extending around a major

portion of the inner periphery of the annular guide plate. The outer wall 21 of the recess 20 extends downwardly to the lowermost surface 22 of the guide plate (see FIG. 3), which is spaced from the top surface of the pad 16 by a distance which is slightly less, e.g., 0.010 inch, than the thickness of the thinnest coins. Consequently, the initial radial movement of the coins is terminated when they engage the wall 21 of the recess 20, though the coins continue to move circumferentially along the wall 21 by the rotational movement of the pad 16. Overlapping coins which only partially enter the recess 20 are stripped apart by a notch 20a formed in the top surface of the recess 20 along its inner edge (see FIG. 4).

The only portion of the central opening of the guide plate 12 which does not open directly into the recess 20 is that sector of the periphery which is occupied by a land 23 whose lower surface is at the same elevation as the lowermost surface 22 of the guide plate. The upstream end of the land 23 forms a ramp 23a (FIG. 5), which prevents certain coins stacked on top of each other from reaching the ramp 24. When two or more coins are stacked on top of each other, they may be pressed into the resilient pad 16 even within the deep peripheral recess 20. Consequently, stacked coins can be located at different radial positions within the channel 20 as they approach the land 23. When such a pair of stacked coins has only partially entered the recess 20, they engage the ramp 23a on the leading edge of the land 23. The ramp 23a presses the stacked coins downwardly into the resilient pad 16, which retards the lower coin while the upper coin continues to be advanced. Thus, the stacked coins are stripped apart so that they can be recycled and once again enter the recess 20, this time in a single layer.

When a stacked pair of coins has moved out into the recess 20 before reaching the land 23, the stacked coins engage the inner spiral wall 26. The vertical dimension of the wall 26 is slightly less than the thickness of the thinnest coin, so the lower coin in a stacked pair passes beneath the wall and is recycled while the upper coin in the stacked pair is cammed outwardly along the wall 26 (see FIGS. 6 and 7). Thus, the two coins are stripped apart with the upper coin moving along the guide wall 26, while the lower coin is recycled.

As coins within the recess 20 approach the land 23, those coins move outwardly around the land 23 and engage a ramp 24 leading into a recess 25 which is an outward extension of the inner peripheral recess 20. The recess 25 is preferably just slightly wider than the diameter of the coin denomination having the greatest diameter. The top surface of the major portion of the recess 25 is spaced away from the top of the pad 16 by a distance that is less than the thickness of the thinnest coin so that the coins are gripped between the

guide plate 12 and the resilient pad 16 as they are rotated through the recess 25. Thus, coins which move into the recess 25 are all rotated into engagement with the outwardly spiralling inner wall 26, and then continue to move outwardly through the recess 25 with the inner edges of all the coins riding along the spiral wall 26.

As can be seen in FIGS. 6-8, a narrow band 25a of the top surface of the recess 25 adjacent its inner wall 26 is spaced away from the pad 16 by approximately the thickness of the thinnest coin. This ensures that coins of all denominations (but only the upper coin in a stacked or shingled pair) are securely engaged by the wall 26 as it spirals outwardly. The rest of the top surface of the recess 25 tapers downwardly from the band 25a to the outer edge of the recess 25. This taper causes the coins to be tilted slightly as they move through the recess 25, as can be seen in FIGS. 6-8, thereby further ensuring continuous engagement of the coins with the outwardly spiraling wall 26.

The primary purpose of the outward spiral formed by the wall 26 is to space apart the coins so that during normal steady-state operation of the sorter, successive coins will not be touching each other. As will be discussed below, this spacing of the coins contributes to a high degree of reliability in the counting of the coins.

Rotation of the pad 16 continues to move the coins along the wall 26 until those coins engage a ramp 27 sloping downwardly from the recess 25 to a region 22a of the lowermost surface 22 of the guide plate 12 (see FIG. 9). Because the surface 22 is located even closer to the pad 16 than the recess, the effect of the ramp 27 is to further depress the coins into the resilient pad 16 as the coins are advanced along the ramp by the rotating disc. This causes the coins to be even more firmly gripped between the guide plate surface region 22a and the resilient pad 16, thereby securely holding the coins in a fixed radial position as they continue to be rotated along the underside of the guide plate by the rotating disc.

As the coins emerge from the ramp 27, the coins enter a referencing and counting recess 30 which still presses all coin denominations firmly against the resilient pad 16. The outer edge of this recess 30 forms an inwardly spiralling wall 31 which engages and precisely positions the outer edges of the coins before the coins reach the exit channels which serve as means for discriminating among coins of different denominations according to their different diameters.

The inwardly spiralling wall 31 reduces the spacing between successive coins, but only to a minor extent so that successive coins remain spaced apart. The inward spiral closes any spaces between the wall 31 and the outer edges of the coins so that the outer edges of all the coins are eventually located at a common radial position, against the wall 31, regardless

of where the outer edges of those coins were located when they initially entered the recess 30.

At the downstream end of the referencing recess 30, a ramp 32 (FIG. 13) slopes downwardly from the top surface of the referencing recess 30 to region 22b of the lowermost surface 22 of the guide plate. Thus, at the downstream end of the ramp 32 the coins are gripped between the guide plate 12 and the resilient pad 16 with the maximum compressive force. This ensures that the coins are held securely in the radial position initially determined by the wall 31 of the referencing recess 30.

Beyond the referencing recess 30, the guide plate 12 forms a series of exit channels 40, 41, 42, 43, 44 and 45 which function as selecting means to discharge coins of different denominations at different circumferential locations around the periphery of the guide plate. Thus, the channels 40-45 are spaced circumferentially around the outer periphery of the plate 12, with the innermost edges of successive pairs of channels located progressively farther away from the common radial location of the outer edges of all coins for receiving and ejecting coins in order of increasing diameter. In the particular embodiment illustrated, the six channels 40-45 are positioned and dimensioned to eject only dimes (channels 40 and 41), nickels (channels 42 and 43) and quarters (channel 44 and 45). The innermost edges of the exit channels 40-45 are positioned so that the inner edge of a coin of only one particular denomination can enter each channel; the coins of all other denominations reaching a given exit channel extend inwardly beyond the innermost edge of that particular channel so that those coins cannot enter the channel and, therefore, continue on to the next exit channel.

For example, the first two exit channels 40 and 41 (FIGS. 2 and 14) are intended to discharge only dimes, and thus the innermost edges 40a and 41a of these channels are located at a radius that is spaced inwardly from the radius of the referencing wall 31 by a distance that is only slightly greater than the diameter of a dime. Consequently, only dimes can enter the channels 40 and 41. Because the outer edges of all denominations of coins are located at the same radial position when they leave the referencing recess 30, the inner edges of the nickels and quarters all extend inwardly beyond the innermost edge 40a of the channel 40, thereby preventing these coins from entering that particular channel. This is illustrated in FIG. 2 which shows a dime D captured in the channel 40, while nickels N and quarters Q bypass the channel 40 because their inner edges extend inwardly beyond the innermost edge 40a of the channel so that they remain gripped between the guide plate surface 22b and the resilient pad 16.

Of the coins that reach channels 42 and 43, the inner edges of only the nickels are

located close enough to the periphery of the guide plate 12 to enter those exit channels. The inner edges of the quarters extend inwardly beyond the innermost edge of the channels 42 and 43 so that they remain gripped between the guide plate and the resilient pad. Consequently, the quarters are rotated past the channel 41 and continue on to the next exit channel. This is illustrated in FIG. 2 which shows nickels N captured in the channel 42, while quarters Q bypass the channel 42 because the inner edges of the quarters extend inwardly beyond the innermost edge 42a of the channel.

Similarly, only quarters can enter the channels 44 and 45, so that any larger coins that might be accidentally loaded into the sorter are merely recirculated because they cannot enter any of the exit channels.

The cross-sectional profile of the exit channels 40-45 is shown most clearly in FIG. 14, which is a section through the dime channel 40. Of course, the cross-sectional configurations of all the exit channels are similar; they vary only in their widths and their circumferential and radial positions. The width of the deepest portion of each exit channel is smaller than the diameter of the coin to be received and ejected by that particular exit channel, and the stepped surface of the guide plate adjacent the radially outer edge of each exit channel presses the outer portions of the coins received by that channel into the resilient pad so that the inner edges of those coins are tilted upwardly into the channel (see FIG. 14). The exit channels extend outwardly to the periphery of the guide plate so that the inner edges of the channels guide the tilted coins outwardly and eventually eject those coins from between the guide plate 12 and the resilient pad 16.

The first dime channel 40, for example, has a width which is less than the diameter of the dime. Consequently, as the dime is moved circumferentially by the rotating disc, the inner edge of the dime is tilted upwardly against the inner wall 40a which guides the dime outwardly until it reaches the periphery of the guide plate 12 and eventually emerges from between the guide plate and the resilient pad. At this point the momentum of the coin causes it to move away from the sorting head into an arcuate guide which directs the coin toward a suitable receptacle, such as a coin bag or box.

As coins are discharged from the six exit channels 40-45, the coins are guided down toward six corresponding bag stations BS by six arcuate guide channels 50, as shown in FIGS. 17 and 18. Only two of the six bag stations BS are illustrated in FIG. 17, and one of the stations is illustrated in FIG. 18.

As the coins leave the lower ends of the guide channels 50, they enter corresponding cylindrical guide tubes 51 which are part of the bag stations BS. The lower ends of these

tubes 51 flare outwardly to accommodate conventional clamping-ring arrangements for mounting coin receptacles or bags B directly beneath the tubes 51 to receive coins therefrom.

As described above, two different exit channels are provided for each coin denomination. Consequently, each coin denomination can be discharged at either of two different locations around the periphery of the guide plate 12, i.e., at the outer ends of the channels 40 and 41 for the dimes, at the outer ends of the channels 43 and 44 for the nickels, and at the outer ends of the channels 45 and 46 for the quarters. In order to select one of the two exit channels available for each denomination, a controllably actuatable shunting device is associated with the first of each of the three pairs of similar exit channels 40-41, 42-43 and 44-45. When one of these shunting devices is actuated, it shunts coins of the corresponding denomination from the first to the second of the two exit channels provided for that particular denomination.

Turning first to the pair of exit channels 40 and 41 provided for the dimes, a vertically movable bridge 80 is positioned adjacent the inner edge of the first channel 40, at the entry end of that channel. This bridge 80 is normally held in its raised, retracted position by means of a spring 81 (FIG. 14), as will be described in more detail below. When the bridge 80 is in this raised position, the bottom of the bridge is flush with the top wall of the channel 40, as shown in FIG. 14, so that dimes D enter the channel 40 and are discharged through that channel in the normal manner.

When it is desired to shunt dimes past the first exit channel 40 to the second exit channel 41, a solenoid S_D (FIGS. 14, 15 and 19) is energized to overcome the force of the spring 81 and lower the bridge 80 to its advanced position. In this lowered position, shown in FIG. 15, the bottom of the bridge 80 is flush with the lowermost surface 22b of the guide plate 12, which has the effect of preventing dimes D from entering the exit channel 40. Consequently, the quarters are rotated past the exit channel 40 by the rotating disc, sliding across the bridge 80, and enter the second exit channel 41.

To ensure that precisely the desired number of dimes are discharged through the exit channel 40, the bridge 80 must be interposed between the last dime for any prescribed batch and the next successive dime (which is normally the first dime for the next batch). To facilitate such interposition of the bridge 80 between two successive dimes, the dimension of the bridge 80 in the direction of coin movement is relatively short, and the bridge is located along the edges of the coins, where the space between successive coins is at a maximum. The fact that the exit channel 40 is narrower than the coins also helps ensure that the outer edge of a coin will not enter the exit channel while the bridge is being moved from its

retracted position to its advanced position. In fact, with the illustrative design, the bridge 80 can be advanced after a dime has already partially entered the exit channel 40, overlapping all or part of the bridge, and the bridge will still shunt that dime to the next exit channel 41.

Vertically movable bridges 90 and 100 (FIG. 2) located in the first exit channels 42 and 44 for the nickels and quarters, respectively, operate in the same manner as the bridge 80. Thus, the nickel bridge 90 is located along the inner edge of the first nickel exit channel 42, at the entry end of that exit channel. The bridge 90 is normally held in its raised, retracted position by means of a spring. In this raised position the bottom of the bridge 90 is flush with the top wall of the exit channel 42, so that nickels enter the channel 42 and are discharged through that channel. When it is desired to divert nickels to the second exit channel 43, a solenoid S_N (FIG. 19) is energized to overcome the force of the spring and lower the bridge 90 to its advanced position, where the bottom of the bridge 60 is flush with the lowermost surface 22b of the guide plate 12. When the bridge 90 is in this advanced position, the bridge prevents any coins from entering the first exit channel 42. Consequently, the nickels slide across the bridge 90, continue on to the second exit channel 43 and are discharged therethrough. The quarter bridge 100 (FIG. 2) and its solenoid S_Q (FIG. 19) operate in exactly the same manner. The edges of all the bridges 80, 90 and 100 are preferably chamfered to prevent coins from catching on these edges.

The details of the actuating mechanism for the bridge 80 are illustrated in FIGS. 14 and 15. The bridges 90 and 100 have similar actuating mechanisms, and thus only the mechanism for the bridge 80 will be described. The bridge 80 is mounted on the lower end of a plunger 110 which slides vertically through a guide bushing 111 threaded into a hole bored into the guide plate 12. The bushing 111 is held in place by a locking nut 112. A smaller hole 113 is formed in the lower portion of the plate 12 adjacent the lower end of the bushing 111, to provide access for the bridge 80 into the exit channel 40. The bridge 80 is normally held in its retracted position by the coil spring 81 compressed between the locking nut 112 and a head 114 on the upper end of the plunger 110. The upward force of the spring 81 holds the bridge 80 against the lower end of the bushing 111.

To advance the plunger 110 to its lowered position within the exit channel 40 (FIG. 15), the solenoid coil is energized to push the plunger 110 downwardly with a force sufficient to overcome the upward force of the spring 81. The plunger is held in this advanced position as long as the solenoid coil remains energized, and is returned to its normally raised position by the spring 81 as soon as the solenoid is de-energized.

Solenoids S_N and S_Q control the bridges 90 and 100 in the same manner described

above in connection with the bridge 80 and the solenoid S_D.

In an alternative embodiment, the bridges 80, 90, and 100 are replaced with rotatable circular pins, and each pair of exit channels for a single denomination is substituted with a single exit channel forming two separate coin paths. For example, as shown in FIGS. 40a-c, the exit channels 40 and 41 for dimes are replaced with an exit channel having two coin paths 40' and 41', and the bridge 80 is substituted with a rotatable pin 80' located at the upstream end of the coin path 41'. Half of the pin 80' extends beyond a wall 41a' of the coin path 41'. The coin path 40' has a slightly greater depth than the coin path 41', and a wall 40a' is located between the two coin paths.

The coin path traversed by the exiting dimes is determined by the rotational position of the pin 80'. When the pin 80' is oriented as shown in FIGS. 40a and 40b, the dimes engage the wall 41a' of the coin path 41' and, therefore, exit the coin sorter via the exit path 41'. If, however, the pin 80' is rotated 90 degrees as shown in FIG. 40c, the pin 80' prevents the dimes from entering the exit path 41' and forces the dimes into the exit path 40'. The bridges 90, 100 and their respective pairs of exit channels are replaced by rotatable pins and exit channels in the same manner as described above for the bridge 80 and the exit channels 40, 41. Thus, the bridge 90 is replaced with a rotatable circular pin, and the exit channels 42, 43 are replaced with a single exit channel having two coin paths. Similarly, the bridge 100 is replaced with a rotatable circular pin, and the exit channels 44, 45 are replaced with a single exit channel having two coin paths.

In another alternative embodiment, the rotatable circular pin corresponding to each coin denomination is modified to have a semi-circular shape. In this case, the coin path traversed by the exiting coins of each denomination is determined by whether the pin is in a retracted or extended position. For example, as shown in FIGS. 41a-c, the rotatable circular pin 80' is replaced with an extendable semi-circular pin 82 located entirely within the exit path 41'. When the pin 82 is in a retracted position such that its lower surface is flush with the surface of the coin path 41' (FIGS. 41a and 41b), the dimes exit the sorter via the exit path 41'. When the pin 82 is in an extended position (FIG. 41c), the pin 82' prevents the dimes from entering the exit path 41' and forces the dimes to exit the sorter via the exit path 40'.

The internal shunting devices described above, including the bridges in FIGS. 14 and 15 and the pins in FIGS. 40a-c and FIGS. 41a-c, are located within the sorting head of the coin sorter. These shunting devices are used to separate coins of a single denomination into two batches. This separation of coins into two batches may also be accomplished by use of

external shunting devices located outside the periphery of the coin sorter. In this situation, the coins of a single denomination may always be directed to a single exit channel, instead of being directed to two separate exit channels or paths. Therefore, in the coin sorter of FIG. 2, one of each pair of exit channels 40-41, 42-43, and 44-45 may be removed. If, however, internal shunting of coins is still desired, these exit channels may still be provided in the sorting head.

One example of an external shunting device for separating coins of a single denomination into two batches is illustrated in FIGS. 42-45. The curved exit chute 1300 includes two slots 1302, 1304 separated by an internal partition 1306. The internal partition 1306 is pivotally mounted to a stationary base 1308 so that the internal partition 1306 may be moved, perpendicular to the plane of the coins, by an actuator 1310 between an up position (FIG. 45) and a down position (FIG. 44). The exit chute 1300 is positioned adjacent an exit channel of the coin sorter such that coins exiting the coin sorter are guided into the slot 1302 when the internal partition 1306 is in the down position (FIG. 44). When a predetermined number of coins of a particular denomination are captured in a bag (not shown) located at the output end of the slot 1302, the actuator 1310 moves the internal partition 1306 to the up position (FIG. 45) so that coins of that denomination now enter the slot 1304 of the exit chute 1300. Coins entering the slot 1304 are captured in another bag (not shown) located at the output end of the slot 1304. While FIGS. 41-45 illustrate an exit chute with only two slots and a single internal partition, it should be apparent that an exit chute with more than two slots and more than one internal partition may be employed to separate coins of a particular denomination into more than two batches.

The actuator 1310 moves the internal partition 1306 between the up and down positions in response to detection of the leading edge of an *n*th coin. Thus, if the internal partition 1306 is in the up position and the leading edge of the *n*th coin is detected, the *n*th coin will enter the slot 1302 and the $n+1$ coin will be diverted into the slot 1304. The leading edges of coins entering the exit chute 1300 may be detected using a sensor positioned adjacent the input end 1312 of the exit chute. In response to detection of the *n*th coin, the sensor triggers the actuator 1310 so as to divert the $n+1$ coin into the slot 1304.

To provide greater physical separation between coins as they leave the coin sorter, an external drive system may be interposed between the exit channel of the coin sorter and the exit chute 1300. An example of such an external drive system is depicted in FIG. 46. In the illustrated drive system, coins from the coin sorter are deposited on a stationary smooth surface 1320 and engaged by a resilient wheel 1322 rotated by a motor 1324. To permit a

firm engagement between the wheel 1322 and the coins passing thereunder, the wheel 1322 is spaced above the surface 1320 by a distance slightly less than the thickness of the coins. In order to increase the physical separation between the coins, the motor 1324 rotates the wheel 1322 at a tangential velocity which is greater than the velocity of the coins as they leave the coin sorter. Following engagement with the wheel 1322, the coins move along the surface 1320 to the exit chute 1300. The coins entering the chute 1300 may be detected by a counting sensor 1326 mounted to the stationary surface 1320. The counting sensor 1326 may also be used to trigger the actuator 1310 to move the internal partition 1306 in response to detection of the *n*th coin. It should be apparent that the external drive system in FIG. 46 could be substituted with various other drive systems which increase the physical separation between coins. For example, the coins may be deposited on a conveyor belt driven at a faster speed than the speed of the coins exiting the coin sorter. Also, the coins may be deposited on a stationary surface with a drive belt spaced thereabove to drive the coins downstream along the stationary surface.

Another example of an external shunting device for separating coins of a particular denomination into two batches is shown in FIGS. 47 and 48. This shunting device includes an exit chute 1400 which is very similar to the exit chute 1300 in FIGS. 42-45, except that the internal partition 1406 remains stationary in the illustrated position at all times. To direct coins into one of the slots 1402, 1404, a pair of pneumatic pumps 1414, 1416 are interposed between the exit channel of the coin sorter and the exit chute 1400. The pneumatic pumps 1414, 1416 are disposed on opposite sides of the coin path, and, while active, they expel a stream of air in a direction generally perpendicular to the coin path. Only one of the two pumps 1414, 1416 is active at any given time. To direct coins into the slot 1404, the upper pneumatic pump 1414 is activated (FIG. 47). Similarly, to direct coins into the slot 1402, the lower pneumatic pump 1416 is activated (FIG. 48). The coins entering the slot 1402 follow the coin path indicated by the reference numeral 1418. The coins passing between the pneumatic pumps 1414, 1416 may be detected using a counting sensor (not shown) positioned upstream relative to the pneumatic pumps. In response to detection of the *n*th coin, the sensor triggers the pneumatic pumps so as to deactivate the active pump and activate the inactive pump.

To provide greater physical separation between coins as they leave the coin sorter, an external drive system may be interposed between the exit channel of the coin sorter and the exit chute 1400 (FIGS. 49 and 50). The drive system in FIGS. 49 and 50 is analogous to the drive system in FIG. 46 and includes the same parts. In particular, coins from the coin

sorter are deposited on a stationary smooth surface 1420 and engaged by a resilient wheel 1422 rotated by a motor (not shown). In order to increase the physical separation between the coins, the wheel 1422 is rotated at a tangential velocity which is greater than the velocity of the coins as they leave the coin sorter. Following engagement with the wheel 1422, the coins are propelled along the surface 1420 and are then diverted to the appropriate slot in the exit chute 1400 by the pneumatic pumps 1414, 1416. The coins entering the shunting device may be detected by a counting sensor 1424 mounted to the stationary surface 1320. The counting sensor 1424 may also be used to trigger the pneumatic pumps 1414, 1416 to switch which of those pumps is active, thereby causing the coins to enter a different one of the slots 1402, 1404.

Yet another example of an external shunting device is shown in FIGS. 51-55. The curved exit chute 1500 includes two slots 1502, 1504 separated by a movable internal partition 1506. A lever 1508 is attached to the upstream end of the internal partition 1506 through a slot 1512 formed in the upper wall of the exit chute 1500. In response to movement of the lever 1508 through the slot 1512 using an actuator (not shown), the internal partition 1506 moves parallel to the plane of the coins, but perpendicular to the coin path, between a first position (FIG. 53) and a second position (FIG. 54). In the first position of the internal partition 1506 coins are guided into the slot 1504, and in the second position coins are guided into the slot 1502. The exit chute 1500 may be positioned immediately adjacent an exit channel of the coin sorter, or an external drive system may be interposed between the exit channel and the exit chute 1500 to provide greater physical separation between coins as they leave the coin sorter (FIG. 55).

A further example of an external shunting device is depicted in FIGS. 56a-b. In this example, coins exiting the coin sorter are deposited on a smooth stationary surface 1600 and transported across the surface 1600 using a drive belt 1602. The stationary surface 1600 has formed therein a pair of exit channels 1604, 1606. Furthermore, a pair of rotatable diverter pins 1608, 1610 are mounted in the surface 1600 for diverting coins away from their coin path in the same plane as the coin path. The orientation of these pins 1608, 1610 determines whether a particular coin is diverted through one of the exit channels 1604, 1606 or whether the coin continues on a linear path across the surface 1600 without being diverted. The pin 1608 is used to divert coins into the exit channel 1604, and the pin 1610 is used to divert coins so that they bypass the exit channel 1606. A container or bag (not shown) is positioned adjacent the downstream end of each of the exit channels 1604, 1606 to capture coins exiting therefrom. Each of the diverter pins 1608, 1610 is provided with an elevated section which

protrudes upward from the surface 1600 in a manner analogous to the rotatable pin 80' in FIGS. 40a-c. In FIGS. 56a-b, the elevated section for a particular pin is that section which is slightly larger than one half of the upper surface of the pin. This elevated section is used to deflect coins from their original coin path.

If the diverter pin 1608 is rotated to its deflecting position, this pin deflects coins entering the surface 1600 into the exit channel 1604 because the lower edges of the coins (as viewed in FIGS. 56a-b) are engaged by the wall 1612 of the exit channel 1604. If neither of the diverter pins 1608, 1610 is oriented in the deflecting position, the coins enter the exit channel 1606 because the upper edges of the coins are engaged by the wall 1614 of the exit channel 1606. If the diverter pin 1608 is not oriented in the deflecting position but the diverter pin 1610 is oriented in the deflecting position, the diverter pin 1610 deflects coins so that they bypass the exit channel 1606 and continue along the surface 1600.

A pair of sensors 1616, 1618 are mounted to the stationary surface 1600 upstream from the respective diverter pins 1608, 1610. These sensors 1616, 1618 may be designed to detect coins for counting purposes, or, as discussed below, may alternatively be designed for discriminating between valid and invalid coins. The shunting device in FIGS. 56a-b is illustrated as separating coins into three batches. Alternatively, the shunting device may be constructed with only one exit channel and diverter pin so as to separate coins into only two batches, or may be constructed with more than two exit channels and diverter pins so as to separate coins into more than three batches.

The external shunting device in FIGS. 57a-b is similar to the shunting device shown in FIGS. 56a-b. The primary difference between these two shunting devices is that the shunting device of FIGS. 57a-b diverts coins downward perpendicular to the plane of the coin path, while the shunting device of FIGS. 56a-b diverts coins to the side in the plane of the coin path. In the shunting device in FIGS. 57a-b, coins exiting the coin sorter are depositing on a smooth stationary surface 1700. The coins are transported across that surface by a drive belt 1702 positioned slightly above and parallel to the surface 1700. The surface 1700 includes an elevated strip section 1704 against which coins bear unless diverted therefrom by one of the diverters 1706, 1708. Using respective solenoids 1710, 1712, the diverters 1706, 1708 are laterally extendable into the coin path through respective lateral slots formed in the elevated strip section 1704 of the surface 1700.

The diverters 1706, 1708 are used to deflect coins away from their original coin path and into the respective apertures 1714, 1716. More specifically, in the retracted position of the diverters 1706, 1708, the coins follow their original coin path with their lower edges (as

viewed in FIGS. 57a-b) bearing against the elevated strip section 1704. The coins do not fall into the apertures 1714, 1716 because the surface 1700 provides continuous support to both the upper and lower edges of the coins (as viewed in FIGS. 57a and 57b). If the diverter 1706 is moved to the extended position, the diverter 1706 deflects a coin away from the elevated strip section 1704 by a sufficient amount that the lower edge of the coin is no longer supported by the surface 1700 adjacent the lower side of the aperture 1714 as it passes over that aperture. As a result, the lower edge of the coin tilts downwardly and the coin drops through the aperture 1714. If the diverter 1706 is in the retracted position but the diverter 1708 is in the extended position, coins are diverted into the aperture 1716 in the same manner as described above. Coins exiting through the apertures 1714, 1716 are captured in respective containers or bags (not shown) positioned beneath the apertures 1714, 1716. Finally, if both of the diverters 1706, 1708 are in the retracted position, coins bypass both of the apertures 1714, 1716 and continue along the surface 1700.

A pair of sensors 1718, 1720 are mounted to the stationary surface 1600 upstream from the respective diverters 1706, 1708. These sensors 1718, 1720 may be designed to detect coins for either counting or discrimination purposes. Like the shunting device in FIGS. 56a-b, the shunting device in FIGS. 57a-b separates coins into three batches. If desired, however, the shunting device may be constructed to separate coins into more or less than three batches by altering the number of diverters and apertures.

Referring back to FIG. 2, as the coins move along the wall 31 of the referencing recess 30, the outer edges of all coin denominations are at the same radial position at any given angular location along the edge. Consequently, the inner edges of coins of different denominations are offset from each other at any given angular location, due to the different diameters of the coins (see FIG. 2). These offset inner edges of the coins are used to separately count each coin before it leaves the referencing recess 30.

As can be seen in FIGS. 2 and 10-12, three coin sensors S_1, S_2 and S_3 in the form of insulated electrical contact pins are mounted in the upper surface of the recess 30. The outermost sensor S_1 is positioned so that it is contacted by all three coin denominations, the middle sensor S_2 is positioned so that it is contacted only by the nickels and quarters, and the innermost sensor S_3 is positioned so that it is contacted only by the quarters. An electrical voltage is applied to each sensor so that when a coin contacts the pin and bridges across its insulation, the voltage source is connected to ground via the coin and the metal head surrounding the insulated sensor. The grounding of the sensor during the time interval when it is contacted by the coin generates an electrical pulse which is detected by a counting system

connected to the sensor. The pulses produced by coins contacting the three sensors S_1, S_2 and S_3 will be referred to herein as pulses P_1, P_2 and P_3, respectively, and the accumulated counts of those pulses in the counting system will be referred to as counts C_1, C_2 and C_3, respectively.

To permit the simultaneous counting of prescribed batches of coins of each denomination using the first counting technique described above, i.e., the subtraction algorithm, counts C_2 and C_3 must be simultaneously accumulated over two different time periods. For example, count C_3 is the actual quarter count C_Q, which normally has its own operator-selected limit C_{QMAX}. While the quarter count C_Q (= C_3) is accumulating toward its own limit C_{QMAX}, however, the nickel count C_N (= C_2 - C_3) might reach its limit C_{NMAX} and be reset to zero to start the counting of another batch of nickels. For accurate computation of C_N following its reset to zero, the count C_3 must also be reset at the same time. The count C_3, however, is still needed for the ongoing count of quarters; thus the pulses P_3 are supplied to a second counter C_3' which counts the same pulses P_3 that are counted by the first counter C_3 but is reset each time the counter C_2 is reset. Thus, the two counters C_3 and C_3' count the same pulses P_3, but can be reset to zero at different times.

The same problem addressed above also exists when the count C_1 is reset to zero, which occurs each time the dime count C_D reaches its limit C_{MAX}. That is, the count C_2 is needed to compute both the dime count C_D and the nickel count C_N, which are usually reset at different times. Thus, the pulses P_2 are supplied to two different counters C_2 and C_2'. The first counter C_2 is reset to zero only when the nickel count C_N reaches its C_{NMAX}, and the second counter is reset to zero each time C_1 is reset to zero when C_D reaches its limit C_{DMAX}.

Whenever one of the counts C_D, C_N or C_Q reaches its limit, a control signal is generated to initiate a bag-switching or bag-stop function.

For the bag-switching function, the control signal is used to actuate the movable shunt within the first of the two exit channels provided for the appropriate coin denomination. This enables the coin sorter to operate continuously (assuming that each full coin bag is replaced with an empty bag before the second bag for that same denomination is filled) because there is no need to stop the sorter either to remove full bags or to remove excess coins from the bags.

For a bag-stop function, the control signal preferably stops the drive for the rotating disc and at the same time actuates a brake for the disc. The disc drive can be stopped either by de-energizing the drive motor or by actuating a clutch which de-couples the drive motor from the disc. An alternative bag-stop system uses a movable diverter within a coin-

recycling slot located between the counting sensors and the exit channels. Such a recycling diverter is described, for example, in U.S. Patent No. 4,564,036 issued January 14, 1986, for "Coin Sorting System With Controllable Stop."

Referring now to FIG. 19, there is shown an upper level block diagram of an illustrative microprocessor-based control system 200 for controlling the operation of a coin sorter incorporating the counting and sorting system of this invention. The control system 200 includes a central processor unit (CPU) 201 for monitoring and regulating the various parameters involved in the coin sorting/counting and bag-stopping and switching operations. The CPU 201 accepts signals from (1) the bag-interlock switches 74 which provide indications of the positions of the bag-clamping rings 72 which are used to secure coin bags B to the six coin guide tubes 51, to indicate whether or not a bag is available to receive each coin denomination, (2) the three coin sensors S_1-S_3, (3) an encoder sensor E_s and (4) three coin-tracking counters CTC_D, CTC_N and CTC_Q. The CPU 201 produces output signals to control the three shunt solenoids S_D, S_N and S_Q, the main drive motor M_1, an auxiliary drive motor M_2, a brake B and the three coin-tracking counters.

A drive system for the rotating disc, for use in conjunction with the control system of FIG. 19, is illustrated in FIG. 16. The disc is normally driven by a main a-c. drive motor M_1 which is coupled directly to the coin-carrying disc 13 through a speed reducer 210. To stop the disc 13, a brake B is actuated at the same time the main motor M_1 is de-energized. To permit precise monitoring of the angular movement of the disc 13, the outer peripheral surface of the disc carries an encoder in the form of a large number of uniformly spaced indicia 211 (either optical or magnetic) which can be sensed by an encoder sensor 212. In the particular example illustrated, the disc has 720 indicia 211 so that the sensor 212 produces an output pulse for every 0.5° of movement of the disc 13.

The pulses from the encoder sensor 212 are supplied to the three coin-tracking down counters CTD_D, CTC_N and CTC_Q for separately monitoring the movement of each of the three coin denominations between fixed points on the sorting head. The outputs of these three counters CTC_D, CTC_N and CTC_Q can then be used to separately control the actuation of the bag-switching bridges 80, 90 and 100 and/or the drive system. For example, when the last dime in a prescribed batch has been detected by the sensors S_1-S_3, the dime-tracking counter CTC_D is preset to count the movement of a predetermined number of the indicia 211 on the disc periphery past the encoder sensor 212. This is a way of measuring the movement of the last dime through an angular displacement that brings that last dime to a position where the bag-switching bridge 80 should be actuated to interpose the bridge between the last dime

and the next successive dime.

In the sorting head of FIG. 2, a dime must traverse an angle of 20° to move from the position where it has just cleared the last counting sensor S_1 to the position where it has just cleared the bag-switching bridge 80. At a disc speed of 250 rpm, the disc turns -- and the coin moves -- at a rate of 1.5° per millisecond. A typical response time for the solenoid that moves the bridge 80 is 6 milliseconds (4 degrees of disc movement), so the control signal to actuate the solenoid should be transmitted when the last dime is 4 degrees from its bridge-clearing position. In the case where the encoder has 720 indicia around the circumference of the disc, the encoder sensor produces a pulse for ever 0.5° of disc movement. Thus the coin-tracking counter CTC_D for the dime is preset to 32 when the last dime is sensed, so that the counter CTC_D counts down to zero, and generates the required control signal, when the dime has advanced 16° beyond the last sensor S_1. This ensures that the bridge 80 will be moved just after it has been cleared by the last dime, so that the bridge 80 will be interposed between that last dime and the next successive dime.

In order to expand the time interval available for any of the bag-switching bridges to be interposed between the last coin in a prescribed batch and the next successive coin of that same denomination, control means may be provided for reducing the speed of the rotating disc 13 as the last coin in a prescribed batch is approaching the bridge. Reducing the speed of the rotating disc in this brief time interval has little effect on the overall throughput of the system, and yet it significantly increases the time interval available between the instant when the trailing edge of the last coin clears the bridge and the instant when the leading edge of the next successive coin reaches the bridge. Consequently, the timing of the interposing movement of the bridge relative to the coin flow past the bridge becomes less critical and, therefore, it becomes easier to implement and more reliable in operation.

Reducing the speed of the rotating disc is preferably accomplished by reducing the speed of the motor which drives the disc. Alternatively, this speed reduction can be achieved by actuation of a brake for the rotating disc, or by a combination of brake actuation and speed reduction of the drive motor.

One example of a drive system for controllably reducing the speed of the disc 13 is illustrated in FIG. 16. This system includes an auxiliary d-c. motor M_2 connected to the drive shaft of the main drive motor M_1 through a timing belt 213 and an overrun clutch 214. The speed of the auxiliary motor M_2 is controlled by a drive control circuit 215 through a current sensor 216 which continuously monitors the armature current supplied to the auxiliary motor M_2. When the main drive motor M_1 is de-energized, the auxiliary d-c. motor M_2 can

be quickly accelerated to its normal speed while the main motor M_1 is decelerating. The output shaft of the auxiliary motor turns a gear which is connected to a larger gear through the timing belt 213, thereby forming a speed reducer for the output of the auxiliary motor M_2. The overrun clutch 214 is engaged only when the auxiliary motor M_2 is energized, and serves to prevent the rotational speed of the disc 13 from decreasing below a predetermined level while the disc is being driven by the auxiliary motor.

Returning to FIG. 19, when the prescribed number of coins of a prescribed denomination has been counted for a given coin batch, the controller 201 produces control signals which energize the brake B and the auxiliary motor M_2 and de-energize the main motor M_1. The auxiliary motor M_2 rapidly accelerates to its normal speed, while the main motor M_1 decelerates. When the speed of the main motor is reduced to the speed of the overrun clutch 214 driven by the auxiliary motor, the brake overrides the output of the auxiliary motor, thereby causing the armature current of the auxiliary motor to increase rapidly. When this armature current exceeds a preset level, it initiates de-actuation of the brake, which is then disengaged after a short time delay. After the brake is disengaged, the armature current of the auxiliary motor drops rapidly to a normal level needed to sustain the normal speed of the auxiliary motor. The disc then continues to be driven by the auxiliary motor alone, at a reduced rotational speed, until the encoder sensor 212 indicates that the last coin in the batch has passed the position where that coin has cleared the bag-switching bridge in the first exit slot for that particular denomination. At this point the main drive motor is re-energized, and the auxiliary motor is de-energized.

Referring now to FIG. 20, there is shown a flow chart 220 illustrating the sequence of operations involved in utilizing the bag-switching system of the illustrative sorter of FIG. 1 in conjunction with the microprocessor-based system discussed above with respect to FIG. 19.

The subroutine illustrated in FIG. 20 is executed multiple times in every millisecond. Any given coin moves past the coin sensors at a rate of about 1.5° per millisecond. Thus, several milliseconds are required for each coin to traverse the sensors, and so the subroutine of FIG. 20 is executed several times during the sensor-traversing movement of each coin.

The first six steps 300-305 in the subroutine of FIG. 20 determine whether the interrupt controller has received any pulses from the three sensors S_1-S_3. If the answer is affirmative for any of the three sensors, the corresponding count C_1, C_2, C_2', C_3 and C_3' is incremented by one. Then at step 306 the actual dime count C_D is computed by subtracting count C_2' from C_1. The resulting value C_D is then compared with the current selected limit

value C_{DMAX} at step 307 to determine whether the selected number of dimes has passed the sensors. If the answer is negative, the subroutine advances to step 308 where the actual nickel count C_N is computed by subtracting count C_3 from C_2. The resulting value C_N is then compared with the selected nickel limit value C_{NMAX} at step 309 to determine whether the selected number of nickels has passed the sensors. A negative answer at step 309 advances the program to step 310 where the quarter count C_Q (=C_3) is compared with C_{DMAX} to determine whether the selected number of quarters has been counted.

When one of the actual counts C_D, C_N or C_Q reaches the corresponding limit C_{DMAX}, C_{NMAX} or C_{QMAC}, an affirmative answer is produced at step 311, 312 or 313.

An affirmative answer at step 311 indicates that the selected number of dimes has been counted, and thus the bridge 80 in the first exit slot 40 for the dime must be actuated so that it diverts all dimes following the last dime in the completed batch. To determine when the last dime has reached the predetermined position where it is desired to transmit the control signal that initiates actuation of the solenoid S_D, step 311 presets the coin-tracking counter CTC_D to a value P_D. The counter CTC_D then counts down from P_D in response to successive pulses from the encoder sensor ES as the last dime is moved from the last sensor S_3 toward the bridge 80. To control the speed of the dime so that it is moving at a known constant speed during the time interval when the solenoid S_D is being actuated, step 314 turns off the main drive motor M1 and turns on the auxiliary d-c. drive motor M2 and the brake B. This initiates the sequence of operations described above, in which the brake B is engaged while the main drive motor M1 is decelerating and then disengaged while the auxiliary motor M2 drives the disc 13 so that the last dime is moving at a controlled constant speed as it approaches and passes the bridge 80.

To determine whether the solenoid S_D must be energized or de-energized, step 315 of the subroutine determines whether the solenoid S_D is already energized. An affirmative response at step 315 indicates that it is bag B that contains the preset number of coins, and thus the system proceeds to step 316 to determine whether bag A is available. If the answer is negative, indicating that bag B is not available, then there is no bag available for receiving dimes and the sorter must be stopped. Accordingly, the system proceeds to step 317 where the auxiliary motor M2 is turned off and the brake B is turned on to stop the disc 13 after the last dime is discharged into bag B. The sorter cannot be re-started again until the bag-interlock switches for the dime bags indicate that the full bag has been removed and replaced with an empty bag.

An affirmative answer at step 316 indicates that bag A is available, and thus the

system proceeds to step 318 to determine whether the coin-tracking counter CTC_D has reached zero, i.e., whether the $OVFL_D$ signal is on. The system reiterates this query until $OVFL_D$ is on, and then advances to step 319 to generate a control signal to de-energize the solenoid S_D so that the bridge 80 is moved to its retracted (upper) position. This causes all the dimes for the next coin batch to enter the first exit channel 40 so that they are discharged into bag A.

A negative answer at step 315 indicates the full bag is bag A rather than bag B, and thus the system proceeds to step 320 to determine whether bag B is available. If the answer is negative, it means that neither bag A nor bag B is available to receive the dimes, and thus the sorter is stopped by advancing to step 317. An affirmative answer at step 320 indicates that bag B is, in fact, available, and thus the system proceeds to step 321 to determine when the solenoid S_D is to be energized, in the same manner described above for step 318. Energizing the solenoid S_D causes the bridge 80 to be advanced to its lower position so that all the dimes for the next batch are shunted past the first exit channel 40 to the second exit channel 41. The control signal for energizing the solenoid is generated at step 321 when step 320 detects that $OVFL_D$ is on.

Each time the solenoid S_D is either energized at step 322 or de-energized at step 319, the subroutine resets the counters C_1 and C_2' at step 323, and turns off the auxiliary motor M2 and the brake B and turns on the main drive motor M1 at step 324. This initializes the dime-counting portion of the system to begin the counting of a new batch of dimes.

It can thus be seen that the sorter can continue to operate without interruption, as long as each full bag of coins is removed and replaced with an empty bag before the second bag receiving the same denomination of coins has been filled. The exemplary sorter is intended for handling coin mixtures of only dimes, nickels and quarters, but it will be recognized that the arrangement described for these three coins in the illustrative embodiment could be modified for any other desired coin denominations, depending upon the coin denominations in the particular coin mixtures to be handled by the sorter.

FIGS. 21-26 illustrate a system in which each coin is sensed after it has been sorted but before it has exited from the rotating disc. One of six proximity sensors S_1-S_6 is mounted along the outboard edge of each of the six exit channels 350-355 in the sorting head. By locating the sensors S_1-S_6 in the exit channels, each sensor is dedicated to one particular denomination of coin, and thus it is not necessary to process the sensor output signals to determine the coin denomination. The effective fields of the sensors S_1-S_6 are all located just outboard of the radius R_g at which the outer edges of all coin denominations are gaged before

they reach the exit channels 350-355, so that each sensor detects only the coins which enter its exit channel and does not detect the coins which bypass that exit channel. Thus, in FIG. 21 the circumferential path followed by the outer edges of all coins as they traverse the exit channels is illustrated by the dashed-line arc R_g. Only the largest coin denomination (e.g., U.S. half dollars) reaches the sixth exit channel 355, and thus the location of the sensor in this exit channel is not as critical as in the other exit channels 350-354.

It is preferred that each exit channel have the straight side walls shown in FIG. 21, instead of the curved side walls used in the exit channels of many previous disc-type coin sorters. The straight side walls facilitate movement of coins through an exit slot during the jogging mode of operation of the drive motor, after the last coin has been sensed, which will be described in more detail below.

To ensure reliable monitoring of coin movement downstream of the respective sensors, as well as reliable sensing of each coin, each of the exit channels 350-355 is dimensioned to press the coins therein down into the resilient top surface of the rotating disc. This pressing action is a function of not only the depth of the exit channel, but also the clearance between the lowermost surface of the sorting head and the uppermost surface of the disc.

To ensure that the coins are pressed into the resilient surface of the rotating disc, the depth of each of the exit channels 350-355 must be substantially smaller than the thickness of the coin exited through that channel. In the case of the dime channel 350, the top surface 356 of the channel is inclined, as illustrated in FIGS. 25 and 26, to tilt the coins passing through that channel and thereby ensure that worn dimes are retained within the exit channel. As can be seen in FIG. 25, the sensor S_1 is also inclined so that the face of the sensor is parallel to the coins passing thereover.

Because the inclined top surface 356 of the dime channel 350 virtually eliminates any outer wall in that region of the channel 350, the dime channel is extended into the gaging recess 357. In the region where the outer edge of the channel 350 is within the radius R_g, the top surface of the dime channel is flat, so as to form an outer wall 358. This outer wall 358 prevents coins from moving outwardly beyond the gaging radius R_g before they have entered one of the exit channels. As will be described in more detail below, the disc which carries the coins can recoil slightly under certain stopping conditions, and without the outer wall 358 certain coins could be moved outwardly beyond the radius R_g by small recoiling movements of the disc. The wall 358 retains the coins within the radius R_g, thereby preventing the missorting that can occur if a coin moves outside the radius R_g before that coin

reaches its exit channel. The inner wall of the channel 350 in the region bounded by the wall 358 is preferably tapered at an angle of about 45° to urge coins engaging that edge toward the outer wall 358.

The inclined surface 356 is terminated inboard of the exit edge 350 of the exit channel to form a flat surface 360 and an outer wall 361. This wall 361 serves a purpose similar to that of the wall 358 described above, i.e., it prevents coins from moving away from the inner wall of the exit channel 350 in the event of recoiling movement of the disc after a braked stop.

As shown in FIGS. 21, 24 and 26, the exit end of each exit channel is terminated along an edge that is approximately perpendicular to the side walls of the channel. For example, in the case of the dime exit channel 350 shown in FIGS. 24-26, the exit channel terminates at the edge 350a. Although the upper portion of the sorting head extends outwardly beyond the edge 350a, that portion of the head is spaced so far above the disc and the coins (see FIG. 26) that it has no functional significance.

Having the exit edge of an exit channel perpendicular to the side walls of the channel is advantageous when the last coin to be discharged from the channel is followed closely by another coin. That is, a leading coin can be completely released from the channel while the following coin is still completely contained within the channel. For example, when the last coin in a desired batch of n coins is closely followed by coin $n+1$ which is the first coin for the next batch, the disc must be stopped after the discharge of coin n but before the discharge of coin $n+1$. This can be more readily accomplished with exit channels having exit edges perpendicular to the side walls.

As soon as any one of the sensors S_1-S_6 detects the last coin in a prescribed count, the disc 359 is stopped by de-energizing or disengaging the drive motor and energizing a brake. In a preferred mode of operation, the disc is initially stopped as soon as the trailing edge of the "last" or *nth* coin clears the sensor, so that the *nth* coin is still well within the exit channel when the disc comes to rest. The *nth* coin is then discharged by jogging the drive motor with one or more electrical pulses until the trailing edge of the *nth* coin clears the exit edge of its exit channel. The exact disc movement required to move the trailing edge of a coin from its sensor to the exit edge of its exit channel, can be empirically determined for each coin denomination and then stored in the memory of the control system. The encoder pulses are then used to measure the actual disc movement following the sensing of the *nth* coin, so that the disc 359 can be stopped at the precise position where the *nth* coin clears the exit edge of its exit channel, thereby ensuring that no coins following the *nth* coin are

discharged.

The flow chart of a software routine for controlling the motor and brake following the sensing of the *nth* coin of any denomination is illustrated in FIGS. 27-29, and corresponding timing diagrams are shown in FIGS. 30 and 31. This software routine operates in conjunction with a microprocessor receiving input signals from the six proximity sensors S_1-S_6 and the encoder 212, as well as manually set limits for the different coin denominations. Output signals from the microprocessor are used to control the drive motor and brake for the disc 359. One of the advantages of this program is that it permits the use of a simple a-c. induction motor as the only drive motor, and a simple electromagnetic brake. The routine charted in FIGS. 27a and 27b is entered each time the output signal from any of the sensors S_1-S_6 changes, regardless of whether the change is due to a coin entering or leaving the field of the sensor. The microprocessor can process changes in the output signals from all six sensors in less time than is required for the smallest coin to traverse its sensor.

The first step of the routine in FIG. 27a is step 500 which determines whether the sensor signal represents a leading edge of the coin, i.e., that the change in the sensor output was caused by metal entering the field of the sensor. The change in the sensor output is different when metal leaves the field of the sensor. If the answer at step 500 is affirmative, the routine advances to step 501 to determine whether the previous coin edge detected by the same sensor was a trailing edge of a coin. A negative answer indicates that the sensor output signal which caused the system to enter this routine was erroneous, and thus the system immediately exits from the routine. An affirmative answer at step 501 confirms that the sensor has detected the leading edge of a new coin in the exit slot, and this fact is saved at step 502. Step 503 resets a coin-width counter which then counts encoder pulses until a trailing edge is detected. Following step 503 the system exits from this routine.

A negative response at step 500 indicates that the sensor output just detected does not represent a leading edge of a coin, which means that it could be a trailing edge. This negative response advances the routine to step 504 to determine whether the previous coin edge detected by the same sensor was a leading edge. If the answer is affirmative, the system has confirmed the detection of a trailing coin edge following the previous detection of a leading coin edge. This affirmative response at step 504 advances the routine to step 505 where the fact that a trailing edge was just detected is saved, and then step 506 determines whether the proper number of encoder pulses has been counted by the encoder pulses in the interval between the leading-edge detection and the trailing-edge detection. A negative answer at either step 504 or step 506 causes the system to conclude that the sensor output

signal which caused the system to enter this routine was erroneous, and thus the routine is exited.

An affirmative answer at step 506 confirms the legitimate sensing of both the leading and trailing edges of a new coin moving in the proper direction through the exit channel, and thus the routine advances to step 507 to determine whether the sensed coin is an $n+1$ coin for that particular denomination. If the answer is affirmative, the routine starts tracking the movement of this coin by counting the output pulses from the encoder.

At step 509, the routine determines whether the drive motor is already in a jogging mode. If the answer is affirmative, the routine advances to step 511 to set a flag indicating that this particular coin denomination requires jogging of the motor. A negative response at step 509 initiates the jogging mode (to be described below) at step 510 before setting the flag at step 511.

At step 512, the routine of FIG. 27b determines whether the most recently sensed coin is over the limit of n set for that particular coin denomination. If the answer is affirmative, the count for that particular coin is added to a holding register at step 513, for use in the next coin count. A negative response at step 512 advances the routine to step 514 where the count for this particular coin is added to the current count register, and then step 515 determines whether the current count in the register has reached the limit of n for that particular coin denomination. If the answer is negative, the routine is exited. If the answer is affirmative, a timer is started at step 516 to stop the disc at the end of a preselected time period, such as 0.15 second, if no further coins of this particular denomination are sensed by the end of that time period. The purpose of this final step 516 is to stop the disc when the nth coin has been discharged, and the time period is selected to be long enough to ensure that the nth coin is discharged from its exit channel after being detected by the sensor in that channel. If a further coin of the same denomination is sensed before this time period has expired, then the disc may be stopped prior to the expiration of the preselected time period in order to prevent the further coin from being discharged, as will be described in more detail below in connection with the jogging sequence routine.

Whenever step 510 is reached in the routine of FIG. 27b, the jog sequence routine of FIGS. 28a and 28b is entered. The first two steps of this routine are steps 600 and 601 which turn off the drive motor and turn on the brake. This is time t_1 in the timing diagrams of FIGS. 30 and 31, and a timer is also started at time t_1 to measure a preselected time interval between t_1 and t_2; this time interval is selected to be long enough to ensure that the disc has been brought to a complete stop, as can be seen from the speed and position curves

in FIGS. 30 and 31. Step 602 of the routine of FIG. 28a determines when the time t_2 has been reached, and then the brake is turned off at step 603.

It will be appreciated that the *n+1* coin may be reached for more than one coin denomination at the same time, or at least very close to the same time. Thus, step 604 of the routine of FIG. 28a determines which of multiple sensed *n+1* coins is closest to its final position. Of course, if an *n+1* coin has been sensed for only one denomination, then that is the coin denomination that is selected at step 604. Step 605 then determines whether the *n+1* coin of the selected denomination is in its final position. This final position is the point at which the *n+1* coin has been advanced far enough to ensure that the *n*th coin has been fully discharged from the exit channel, but not far enough to jeopardize the retention of the *n+1* coin in the exit channel. Ideally, the final position of the *n+1* coin is the position at which the leading edge of the *n+1* coin is aligned with the exit edge 350a of its exit channel.

When the *n+1* coin has reached its final position, step 605 yields an affirmative response and the routine advances to step 606 where a message is displayed, to indicate that the *nth* coin has been discharged. The routine is then exited. If the response at step 605 is negative, the drive motor is turned on at step 607 and the brake is turned on at step 608. This is time t_3 in the timing diagrams of FIGS. 30 and 31. After a predetermined delay interval, which is measured at step 609, the brake is turned off at time t_4 (step 610). Up until the time t_4 when the brake is turned off, the brake overrides the drive motor so that the disc remains stationary even though the drive motor has been turned on. When the brake is turned off at time t_4, however, the drive motor begins to turn the disc and thereby advance both the *n+1* coin and the *n*th coin along the exit channel.

Step 611 determines when the *n+1* coin has been advanced through a preselected number of encoder pulses. When step 611 produces an affirmative response, the brake is turned on again at step 612 and the motor is turned off at step 613. This is time t_5 in the timing diagrams. The routine then returns to step 602 to repeat the jogging sequence. This jogging sequence is repeated as many times as necessary until step 605 indicates that the *n+1* coin has reached the desired final position. As explained above, the final position is the position at which the *n+1* coin is a position which ensures that the *n*th coin has been discharged from the exit channel and also ensures that the *n+1* coin has not been discharged from the exit channel. The routine is then exited after displaying the limit message at step 606.

Instead of releasing the brake abruptly at time t_4, as indicated in the timing diagram of FIG. 30, the brake may be turned only partially off at step 610 and then released

gradually, according to the subroutine of FIG. 29 and the timing diagram of FIG. 31. In this "soft" brake release mode, step 614 measures small time increments following time t_4, and at the end of each of these time increments step 615 determines whether the brake is fully on or fully off. If the answer is affirmative, the subroutine exits to step 611. If the answer is negative, the brake power is decreased slightly at step 616. This subroutine is repeated each time the jogging sequence is repeated, until step 615 yields an affirmative response. The resulting "soft" release of the brake is illustrated by the steps in the brake curve following time t_4 in FIG. 31.

Yet another important feature embodied by the principles of the present invention concerns the steps of detecting and processing invalid coins. Use of the term "invalid coin" refers to items being circulated on the rotating disc that are not one of the coins (including tokens) to be sorted. For example, it is common that foreign or counterfeit coins enter the coin sorting system. So that such items are not sorted and counted as valid coins, it is helpful to detect and discard the invalid coins from the sorting system. FIG. 32a illustrates a block diagram of a circuit arrangement that may be used for this purpose.

The circuit arrangement of FIG. 32a includes an oscillator 1002 and a digital signal processor (DSP) 1004, which operate together to detect invalid coins passing under the coil 1006. The coil 1006 is located in the sorting head and is slightly recessed so that passing coins do not contact the coil 1006. The dotted lines, shorting the coil 1006 and connecting another coil 1006, illustrate an alternative electrical implementation of the sensing arrangement. The DSP internally converts analog signals to corresponding digital signals and then analyzes the digital signals to determine whether or not the coin under test is a valid coin. The oscillator 1002 sends an oscillating signal through an inductor 1006. The oscillating signal on the other side of the inductor 1006 is level-adjusted by an amplifier 1007 and then analyzed for phase, amplitude and/or harmonic characteristics by the DSP 1004. The phase, amplitude and/or harmonic characteristics are respectively analyzed and recorded in symbolic form by the DSP 1004 in the absence of any coin passing by the inductor 1006 and also for each coin denomination when a coin of that denomination is passing by the inductor 1006. These recordings are made in the factory, or during set up, before any actual sorting of coins occurs. The characteristics for no coin passing by the inductor 1006 are recorded in memory which is internal to the DSP 1004, and the characteristics for each coin denomination when a coin of that particular denomination is passing by the inductor 1006 are respectively stored in memory circuits 1008, 1010 and 1012. The memory circuits 1008, 1010, 1012 depict an implementation for sorting three denominations of coins, dimes, pennies

and nickels, but more or fewer denominations can be used.

With these recordings in place, each time a valid or invalid coin passes by the inductor 1006, the DSP 1004 provides an enable signal (on lead 1013) and an output signal for each of the digital multi-bit comparators 1014, 1016, 1018. When a valid coin passes by the inductor 1006, the output signal corresponds to the characteristics recorded in symbolic form for the subject coin denomination. This output signal is received by each of the comparators 1014, 1016 and 1018 along with the recorded multi-bit output in the associated memory circuit 1014, 1016, 1018. The comparator 1014, 1016 or 1018 for the subject coin denomination generates a high-level (digital "1") output to inform the controller that a valid coin for the subject denomination has been sensed. Using the timing provided by the enable signal, the controller then maintains a count of the coins sensed by the circuit arrangement of FIG. 32a.

When an invalid coin passes by the inductor 1006, the output signal provided by the DSP 1004 does not correspond to the characteristics recorded in symbolic form for any of the subject coin denominations. None of the comparators 1014, 1016 and 1018 provides an output signal indicating that a "match" has occurred and the output of each comparator 1014, 1016, 1018 therefore remains at a low level. These low-level outputs from the comparators 1014, 1016, 1018 are combined via a NOR gate 1019 to produce a high-level output for an AND gate 1020. When the enable signal is present, the AND gate 1020 produces a high-level signal indicating that a invalid coin has passed by the inductor 1006 (or sensor/discriminator circuit).

If desired and also using the timing provided by the enable signal, the controller maintains a count of the invalid coins sensed by the circuit arrangement of FIG. 32a. The number of detected invalid coins is then displayed on a display driven by the controller.

For further information with respect to the operation of the oscillator 1002, the digital signal processor 1004, the memory circuits 1008, 1010, 1012 and the comparators 1014, 1016, 1018, reference may be made to U.S. Patent No. 4,579,217 to Rawicz-Szcerbo, entitled Electronic Coin Validator, which is incorporated herein by reference. It should be noted that the coin-equivalent circuits discussed therein may be used in combination with the above-described implementation of the present invention.

An alternative circuit arrangement for sensing valid coins and discriminating invalid coins is shown in FIG. 32b. This circuit arrangement includes a low-frequency oscillator 1021 and a high-frequency oscillator 1022 providing respective which are summed via a conventional summing circuit 1023. Once amplified using an amplifier 1024, the signal from

the output of the summing circuit 1023 is transmitted through a first coil 1025 for reception by a second coil 1026. Preferably, the coils 1025 and 1026 are arranged within a sensor housing (depicted in dotted lines), which is mounted within the underside of the fixed guide plate, so that a coin passing thereunder attenuates the signal received by the second coil 1026. The amount of attentuation is dependent, for example, on a coin's thickness and conductivity.

In this manner, the signal received by the coil 1026 has characteristics which are unique to the condition in which no coin is present under the sensor housing and to each respective type of coin passing under the sensing housing. By using a high-frequency oscillator 1021, e.g., operating at 25 KHz, and a low-frequency oscillator 1021, e.g., operating at 2 KHz, there is a greater likelihood that the signal difference between the various coins will be detected. Thus, after the signal received by the coil 1026 is amplified by an amplifier 1027, it is processed along a first signal path for analyzing the high-frequency component of the signal and along a second signal path for analyzing the low-frequency component of the signal.

From a block diagram perspective, the circuit blocks in each of the first and second signal paths are similar and corresponding designating numbers are used to illustrate this similarity.

There are essentially two modes of operation for the circuit of FIG. 32b, a normal mode in which there is no coin passing below the sensor housing and a sense mode in which a coin is passing below the sensor housing.

During the normal mode, the high-frequency components of the received signal are passed through a high-pass filter 1028, amplified by a gain-adjustable ampllifier 1029, converted to a DC signal having a voltage which corresponds to the received signal and sent through a switch 1032 which is normally closed. At the other side of the switch 1032, the signal is temporarily preserved in a voltage storage circuit 1033, amplified by an amplifier 1034 and, via an analog-to-digital converter (ADC) 1035, converted to a digital word which a microcomputer (MPU) 1036 analyzes to determine the characteristics of the signal when no coin is passing under the sensor housing. During this normal mode, the gain of the gain-adjustable amplifier 1029 is set according to an error correcting comparator 1030, which receives the output of the amplifier 1034 and a reference voltage (V_{Ref}) and corrects the output of the amplifier 1034 until the output of the amplifier matches the reference voltage. In this way, the microcomputer 1036 uses the signal received by the coil 1026 as a reference for the condition of the received signal just before a coin passes under the coil 1026. Because this reference is regularly adjusted, any tolerance variations in the components used

to implement the circuit arrangement of FIG. 32b is irrelevant.

As a coin passes under the sensor housing, a sudden rise is exhibited in the signal at the output of the signal converter 1031. This signal change is sensed by an edge detector 1037, which responds by immediately opening the switch 1032 and notifying the microcomputer 1036 that a coin is being sensed. The switch 1032 is opened to preserve the voltage stored in the voltage storage circuit 1033 and provided to the microcomputer 1036 via the ADC 1035. In response to being notified of the passing coin, the microcomputer 1036 begins comparing the signal at the output of the signal converter 1031, via an ADC 1038, with the voltage stored in the voltage storage circuit 1033. Using the difference between these two signals to define the characteristics of the passing coin, the microcomputer 1036 compares these characteristics to a predetermined range of characteristics for each valid coin denomination to determine which of the valid coin denominations matches the passing coin. If there is no match, the microcomputer 1036 determines that the passing coin is invalid. The result of the comparison is provided to the controller at the output of the microcomputer 1036 as one of several digital words, e.g., respectively corresponding to "one cent," "five cents," "ten cents," "invalid coin."

The signal path for the low-frequency component is generally the same, with the microcomputer 1036 using the signals in each signal path to determine the characteristics of the passing coin. It is noted, however, that the edge detector circuit 1037 is responsive only to the signal in the high-frequency signal path. For further information concerning an exemplary implementation of the structure and/or function of the blocks 1021-1034, 1037 illustrated in FIG. 32b, reference may be made to U.S. Patent No. 4,462,513.

The predetermined characteristics for the valid coin denominations are stored in the internal memory of the microcomputer 1036 using a tolerance-calibration process, for each valid coin denomination. The process is implemented using a multitude of coins for each coin denomination. For example, the following process can be used to establish the predetermined characteristics for nickels and dimes. First, the sorting system is loaded with nickels only (the greater the quantity and diversity of type (age and wear level), the more accurate the tolerance range will be). With the switches 1032 and 1032' closed and the microcomputer 1036 programmed to store the high and low frequency attenuation values for each nickel, the sorting system is activated until each nickel is passed under the sensor housing. The microcomputer then searches for the high and low values, for the low frequency and the high frequency, for the set of nickels passing under the sensor housing. The maximum value and the minimum value are stored and used as the outer boundaries,

defining the tolerance range for the nickel coin denomination. The same process is repeated for dimes.

Accordingly, the respective circuit arrangements of FIGS. 32a and 32b inform the controller when a valid coin or an invalid coin passes by the inductor 1006, whether the coin is valid or invalid, and, if valid, the type of coin denomination. By using this circuit arrangement of FIG. 32 in combination with a properly configured stationary guide plate, the controller is able to provide an accurate count of each coin denomination, to provide accurate exact bag stop (EBS) sorting, and to detect invalid coins and prevent their discharge as a valid coin.

In addition to the coin sensor/discriminators described in U.S. Patent Nos. 4,462,513 and 4,579,217, various other types of coin sensor/discriminators which are well-known to the art may be mounted in the stationary sorting head 12 for discriminating between valid and invalid coins. These coin sensor/discriminators detect invalid coins on the basis of an examination of one or more of the following coin characteristics: coin thickness; coin diameter; imprinted or embossed configuration on coin face (e.g., penny has profile of Abraham Lincoln, quarter has profile of George Washington, etc.); smooth or milled peripheral edge of coin; coin weight or mass; metallic content of coin; conductivity of coin; impedance of coin; ferromagnetic properties of coin; imperfections such as holes resulting from damage or otherwise; and optical reflection characteristics of coin. Examples of such coin sensor/discriminators are described in several U.S. patents, including U.S. Patent No. 3,559,789 to Hastie et al., U.S. Patent No. 3,672,481 to Hastie et al., U.S. Patent No. 3,910,394 to Fujita, U.S. Patent No. 3,921,003 to Greene, U.S. Patent No. 3,978,962 to Gregory, Jr., U.S. Patent No. 3,980,168 to Knight et al., U.S. Patent No. 4,234,072 to Prumm, U.S. Patent No. 4,254,857 to Levasseur et al., U.S. Patent No. 4,326,621 to Davies, U.S. Patent No. 4,353,452 to Shah et al., U.S. Patent No. 4,483,431 to Pratt, U.S. Patent No. 4,538,719 to Gray et al., U.S. Patent No. 4,667,093 to MacDonald, U.S. Patent No. 4,681,204 to Zimmerman, U.S. Patent No. 4,696,385 to Davies, U.S. Patent No. 4,715,223 to Kaiser et al., U.S. Patent No. 4,963,118 to Gunn et al., U.S. Patent No. 4,971,187 to Furuya et al., U.S. Patent No. 4,995,497 to Kai et al., U.S. Patent No. 5,002,174 to Yoshihara, U.S. Patent No. 5,021,026 to Goi, U.S. Patent No. 5,033,602 to Saarinen et al., U.S. Patent No. 5,067,604 to Metcalf, U.S. Patent No. 5,141,443 to Rasmussen et al., and U.S. Patent No. 5,213,190 to Furneaux et al. The descriptions of the coin sensor/discriminators in the foregoing patents are incorporated herein by reference.

The present invention encompasses a number of ways to detect and process the

invalid coins. They can be categorized in one or more of the following types: continual recycling, inboard deflection (or diversion), and outboard deflection.

A sorting arrangement for the first and second categories, continual recycling and inboard deflection, is illustrated in FIGS. 33 and 34. FIGS. 33 and 34 show the perspective view for the guide plate 12' (with the resilient disc 16) and the bottom view for the guide plate 12', respectively, for this sorting arrangement. Except for certain changes to be discussed below, FIGS. 33 and 34 represent the same sorting arrangement as that shown in FIGS. 17.

In FIGS. 33 and 34, a sensor/discriminator is located in an area on the guide plate 12' after the coins are aligned and placed in single file but before they reach the exit paths 40' through 45'. The guide plate 12' includes a diverter 1040 in each coin exit path 40' through 45'. These diverters are used to prevent a coin (valid or invalid) from entering the associated coin exit path. Using a solenoid, the diverter is forced down from within the guide plate 12' and into line with the inside wall recess of the exit path, so as to prevent the inner edge of the coin from catching the inside wall recess as the coin rotates along the exit paths. By locating the sensor / discriminator ("S/D" or inductor 1006 of FIG. 32) upstream of the coin exit paths and selectively engaging each of the diverters (1040a, 1040b, etc.) in response to detecting an invalid coin, the controller (FIG. 19) prevents the discharge of an invalid coin into one of the coin exit paths for a valid coin.

An implementation of the continual recycling technique is accomplished by sequentially engaging each of the diverters (1040a, 1040b, etc.) in response to detecting an invalid coin using the controller. This forces any invalid coin to recycle back to the center of the rotating disc 16. Based on the speed of the machine and/or rotation tracking using the encoder, the controller sequentially disengages each of the diverters (1040a, 1040b, etc.) as soon as the invalid coin passes by the associated coin exit path. In this way, invalid coins are continually recycled with the valid coins being sorted and properly discharged as long as the diverters are not engaged. Once the sorter has discharged all (or a significant quantity) of the valid coins, the invalid coins are manually removed and discarded, or automatically discarded using one of the invalid-coin discharge techniques discussed below.

In certain higher-speed implementations, the time required to engage a diverter after sensing the presence of an invalid coin may require slowing down the speed at which the disc is rotating. Speed reduction for this purpose is preferably accomplished using one of the previously discussed brake and/or clutch implementations, as described for example in connection with FIGS. 16. This also applies for any of the implementations that are

described below.

An implementation of the inboard deflection technique is accomplished by using one of the coin exit paths (for example, coin exit path 45') to discard invalid coins. This coin exit path can either be dedicated solely for discharging invalid coins or can be used selectively for discharging coins of the largest coin denomination and invalid coins.

Assuming that the coin exit path 45' is dedicated solely for discharging invalid coins, the implementation is as follows. In response to the S/D indicating the presence of an invalid coin, the controller sequentially engages each of the diverters 1040a through 1040e; that is, all of the diverters except the last one which is associated with coin exit path 45'. This forces the detected invalid coin to rotate past each of the coin exit paths 40' through 44'. Assuming that the width of the coin exit path 45' is sufficiently large to accommodate the detected invalid coin, it will be discarded via this coin exit path 45'. Based on the speed of the machine and/or tracking using the encoder, the controller sequentially disengages each of the diverters (1040a, 1040b, etc.) as soon as the invalid coin passes by the associated coin exit path. In this way, invalid coins are discarded as they are sensed with most, if not all, valid coins being sorted and properly discharged as long as their diverters are not engaged. Once the sorter has discharged all (or a significant quantity) of the valid coins, any valid coins that may be inadvertently discarded are manually retrieved and inserting back into the system.

Assuming that the coin exit path 45' is used selectively for discharging coins of the largest coin denomination and invalid coins, the above-described implementation is modified slightly. After forcing the detected invalid coins into the coin exit path 45' along with sorted coins of the largest denomination, the bag into which these valid and invalid coins were discharged are returned into the system for operation and sorted using the continually recycling technique, as described above, to separate the valid coins from the invalid coins. Thereafter, the bag of the sorted coins of the largest denomination is removed. The invalid coins remaining in the system are then removed manually or the above-described inboard deflection technique is used with the coin exit path 45' for discharging the invalid coins.

Another implementation of the inboard deflection technique diverts invalid coins to an exit location dedicated to invalid coins. Referring back to FIGS. 40a-c and FIGS. 41a-c, each of the exit channels in the sorting head may be provided with two exit paths. Instead of or in addition to using these exit channels for separating valid coins into two batches, the exit channels may be used to separate invalid coins from valid coins. Therefore, in FIGS. 40a-c the rotatable pin 80' is in the normal position of FIGS. 40a-b to direct valid coins through the

exit path 41' and is in the rotated position of FIG. 40c to direct invalid coins through the exit path 40'. Similarly, in FIGS. 41a-c the extendable pin 82 is in the normal position of FIGS. 41a-b to direct valid coins through the exit path 41' and is in the extended position of FIG. 41c to direct invalid coins through the exit path 40'.

It should be apparent that the exit channel configuration shown in FIGS. 40a-c and 41a-c may be provided for the exit channel 45' in FIG. 34 and then used in conjunction with the diverters 1040a through 1040e to discard all invalid coins via the exit channel 45'. More specifically, in response to the S/D indicating the presence of an invalid coin, the controller sequentially engages each of the diverters 1040a through 1040e; that is, all of the diverters except the last one which is associated with coin exit path 45'. This forces the detected invalid coin to rotate past each of the coin exit paths 40' through 44'. With the channel 45' configured as shown in FIGS. 40a-c and 41a-c, a rotatable or extendable pin is used to separate the invalid coin from the valid coins.

The sensors S1-S6 in FIG. 34 are not necessary, but may be optionally used to verify, or in place of, the coin-denomination counting function performed in connection with the S/D. By using the sensors S1-S6 in place of the coin-denomination counting function performed in connection with the S/D, the processing time required for the circuit of FIG. 32 is significantly reduced.

An implementation of the outboard deflection technique is illustrated in FIGS. 35 and 36. FIG. 35 is similar to FIG. 33, except that the guide plate of FIG. 35 includes a sensor/discriminator (S/D_2) in the coin exit path and a coin deflector 1050 outboard of the periphery of the disc 16. The use of S/D_1 prior to the exit path and S/D_2 in the exit path provides for a dual check on coin validity. The coin deflector 1050 just outside the disc is engaged by the controller in response to the sensor discriminator (S/D_2) detecting an invalid coin exiting the coin exit path. FIG. 36 shows the coin deflector 1050 from a side perspective deflecting an invalid coin, depicted by the notation NC.

The sensor/discriminator (S/D_1) is not a necessary element, but may be used to reduce the sorting speed (via the jogging mode discussed supra) when an invalid coin passes under the sensor/discriminator (S/D_1). By reducing the sorting speed in this manner, the controller has more time to engage the deflector 1050 to its fullest coin-deflecting position. Preferably, the sorting system includes a coin sensor/discriminator in each coin exit path with an associated deflector located outboard for deflecting invalid coins which enter the coin exit path. Positioning a coin sensor/discriminator in each coin exit channel permits the controller to directly count coin denominations as they pass through their respective exit channels.

Alternative implementations of the outboard deflection technique are illustrated in FIGS. 42-57. Since these external shunting devices have already been described herein, they will not be described again in detail. It suffices to say that the shunting devices may be used not only to separate coins of a particular denomination into two batches, but may also be used to separate invalid coins from valid coins. For example, in FIGS. 42-46 the internal partition 1306 is manipulated by the motor 1310 so as to direct valid coins through one of the slots 1302, 1304 and to direct invalid coins through the other of the slots 1302, 1304. Similarly, in FIGS. 47-50 the pneumatic pumps 1414, 1416 direct valid coins through one of the slots 1402, 1404 and direct invalid coins through the other of the slots 1402, 1404. In FIGS. 51-55 the internal partition 1506 is manipulated to direct valid coins through one of the slots 1502, 1504 and to direct invalid coins through the other of the slots 1502, 1504.

A discrimination sensor, such as the sensor 1326 in FIG. 46, the sensor 1424 in FIGS. 49-50, and the sensor 1514 in FIG. 55, may be positioned just upstream relative to each of the foregoing shunting devices for external detection of invalid coins. In response to the detection of an invalid coin, the discrimination sensor triggers the shunting device to divert (off-sort) the invalid coin down a different coin path than that taken by the valid coins. For example, the sensor 1326 in FIG. 46 may trigger the motor 1310 controlling the internal partition 1306 so that invalid coins are directed through a predetermined one of the slots 1302, 1304. The sensor 1424 in FIGS. 49-50 may trigger the pneumatic pumps 1414, 1416 so that invalid coins are directed to a predetermined one of the slots 1402, 1404. Similarly, the sensor 1514 in FIG. 55 may manipulate the internal partition 1506 so that invalid coins are directed to a predetermined one of the slots 1502, 1504.

In FIGS. 56a-b the diverter pins 1608, 1610 direct invalid coins through a first exit channel 1604, and direct valid coins either through a second exit channel 1606 or to the downstream end of the stationary surface 1600. Thus, valid coins are separated into two batches, with one batch passing through the exit channel 1606 and the other batch bypassing the exit channel 1606 and continuing along the surface 1600. A discrimination sensor 1616 is mounted to the stationary surface 1600 upstream relative to the diverter pin 1608. This sensor 1616 discriminates between valid and invalid coins. In response to detection of an invalid coin, the sensor 1616 triggers the diverter pin 1608 to deflect the invalid coin into the exit channel 1604. Following deflection of the invalid coin, the diverter pin 1608 returns to a nondeflecting position. A counting sensor 1618 is mounted to the stationary surface 1600 upstream relative to the diverter pin 1610. This sensor 1618 counts valid coins as they pass over the sensor, and may also be used to trigger the diverter pin 1610 following detection of

a predetermined number *n* of valid coins. Thus, after the *n*th valid coin is detected by the sensor 1618, the sensor 1618 triggers the diverter 1610 such that the subsequent coins bypass the exit channel 1606 and continue along the surface 1600.

In an alternative embodiment, both of the exit channels 1604, 1606 are used for valid coins for separation into two batches, and invalid coins bypass both of the exit channels 1604, 1606. In another alternative embodiment, the shunting device is provided with only one diverter pin and one exit channel, and invalid coins are diverted into that exit channel.

The shunting device in FIGS. 57a-b may be used in a similar manner to the shunting device in FIGS. 56a-b to separate valid coins from invalid coins. A discrimination sensor 1718 is used to detect invalid coins and trigger the solenoid 1710 in response thereto. A counting sensor 1720 is used to count valid coins and trigger the solenoid 1712 in response to the detection of a predetermined number of valid coins.

FIG. 38 depicts a sorting head in which each of the exit channels 40' through 45' is provided with its own coin sensor/discriminator. These coin sensor/discriminators are designated as S/D_1 through S/D_6. With this arrangement of coin sensor/discriminators, each exit channel is monitored by its respective coin sensor/discriminator for invalid coins. FIG. 39 is a side view showing the coin sensor/discriminator S/D_1 mounted in the guide plate 12 above the exit channel 40'. The other coin sensor/discriminators are mounted in similar fashion in the guide plate 12 above their respective exit channels. If the guide channel 50 associated with each exit channel is also provided with its own coin deflector (see FIG. 36), then the coin deflector of a particular guide channel is engaged by the controller in response to the sensor discriminator detecting an invalid coin exiting the exit channel associated with that guide channel. If desired, the controller can also maintain separate counts of the invalid coins sensed by each sensor/discriminator as previously described.

For each of the various arrangements of coin sensor/discriminators described above, the jogging mode may be used in combination with the encoder to track an invalid coin once it has been sensed. For example, in the arrangement of FIG. 38 where a sensor/discriminator is located in each of the exit channels 40' through 45', the disc is stopped by de-energizing or disengaging the drive motor and energizing the brake. The disc is initially stopped as soon as the trailing edge of an invalid coin in an exit channel clears the sensor/discriminator located in that exit channel, so that the invalid coin is well within the exit channel when the disc comes to a rest. The invalid coin is then discharged by jogging the drive motor with one or more electrical pulses until the trailing edge of the invalid coin clears the exit edge of its exit channel.

Another important aspect of the present invention concerns the capability of the system of FIG. 34 (or one of the other systems illustrated in the drawings) operating in a selected one of four different modes. These modes include an automatic mode, an invalid mode, a fast mode and a normal mode. The automatic mode involves initially running the sorting system for a normal mix of coin denominations and changing the sorting speed if the rate of invalid coins being detected is excessive or the rate of coins of a single coin denomination is excessive. By using the sensor/discriminator to educate the controller as to the type of coin mix, the controller can control the speed of the sorting system to optimize the sorting speed and accuracy. The invalid mode is manually selected by the user of the sorting system to run the sorting system at a slower speed. This mode insures that no invalid coin will be counted and sorted as one of the valid coin denominations. The fast mode is manually selected, and it involves the sorting system determining which of the coin denominations is dominant and sorting for that coin denomination at a higher sorting speed. The normal mode is also manually selected to run the sorting system without taking any special action for an excessive rate of invalid coins or coins of a particular denomination which dominate the mix of coins. FIG. 37 illustrates a process for programming the controller to accommodate these four sorting modes.

The flow chart begins at block 1200 where the sorting system displays each of the four sorting run options. From block 1200, flow proceeds to block 1202 where the controller begins waiting for the user to select one of the four modes. At block 1202, the controller determines if the automatic (auto) mode has been selected. If not, flow proceeds to block 1204 where the controller determines if the invalid mode has been selected. If neither the auto mode nor the invalid mode has been selected, flow proceeds to block 1206 where the controller determines if the fast mode has been selected. Finally, flow proceeds to block 1208 to determine if the normal mode has been selected. If none of the modes have been selected, flow returns from block 1208 to block 1200 where the controller continues to display the run option.

From block 1202, flow proceeds to block 1210 in response to the controller determining that the user has selected the auto mode. At block 1210, the controller runs the sorting system for a typical mix of coin denominations. From block 1210, flow proceeds to block 1212 where the controller begins tracking the rate of coins being sensed per minute, for each coin denomination. This can be done using one of the circuit arrangements shown in FIGS. 32a and 32b. From block 1214, flow proceeds to block 1216 in response to the controller determining that the rate of invalid coins being sensed is greater than a

predetermined threshold (X coins/minute), e.g., X = 5. This threshold can be selected for the particular application at hand.

At block 1216, the controller decreases the sorting speed by a certain amount (z%), for example, 10%. This is done to increase the accuracy of the sorting for invalid coins.

From block 1216 flow proceeds to block 1218 where the controller monitors the invalid coin rate to determine if the invalid coin rate has decreased significantly. At block 1220, the controller compares the invalid coin rate to a threshold somewhat less than the predetermined threshold (x) described in connection with block 1214. For example, if the predetermined threshold is five coins per minute, then the threshold used in connection with block 1220 (x - n) can be set at two coins per minute (x - n = 2). This provides a level of hysteresis so that the controller does not change the sorting speed excessively. From block 1220, flow proceeds to block 1222 to determine if the sorting system has completely sorted out coins. A sensor/discriminator determines that sorting is complete when the sensor/discriminator fails to sense any coins (valid or invalid) for more than a predetermined time period. If sorting is not complete, flow proceeds from block 1222 to block 1224 where the where the controller increases the sorting speed by the same factor (z) as was used to reduce the sorting speed. From block 1224, flow returns to block 1210 where the controller continues to run the sorting operation for a normal mix of coin denominations and repeats this same process. From block 1222, flow proceeds to block 1226 in response to the controller determining that sorting of all coins has been completed. At block 1226, the controller shuts down the machine to end the sorting process, and returns to block 1200 to provide the user with a full display and the ability to select one of the four run options again.

If the auto mode is not selected (block 1202) and the invalid mode is selected, flow proceeds from block 1204 to block 1244 where the controller decreases the sorting speed by a predetermined factor (Z %). From block 1244, flow proceeds to block 1254, where the sorting system continues to sort until the sorting is complete. This mode can be selected by the user when the user is concerned that there may be an excessive number of invalid coins and wants to decrease the possibility of missorting. Thus, the sorting system sorts at a slower sorting rate from the very beginning of the sorting process.

If the user selects the fast mode, flow proceeds from block 1206 to block 1246 where the controller begins counting and comparing each of the coin denominations to determine which of the coin denominations is dominant. For example, if after thirty seconds of sorting, the controller determines that most of the coins in the system are dimes, the controller designates the dime denomination as the dominant one. From block 1246, flow proceeds to

block 1248 where the controller uses the diverters (FIG. 34) to block all coin exit paths other than the exit path for dimes. From block 1248, flow proceeds to block 1250 where the controller increases the sorting speed by a predetermined factor (P %), for example, 10 %. In this manner, the controller learns which of the coin denominations is the dominant one and sorts only for that denomination at a higher speed. The exit paths for the other coin denominations are blocked to minimize a coin being missorted.

If the user selects the normal mode, flow proceeds from block 1208 to block 1252 where the controller runs the sorting system for a normal mix of coin denominations. Because the controller is taking no special action for an excessive number of invalid coins or a dominant coin denomination, the controller runs the sorting system as previously described until the sorting of all coins has been completed, as depicted at block 1254. From block 1254, flow proceeds to block 1256 where the controller terminates the sorting process and then proceeds to block 1200 to permit the user to select another run option.

Accordingly, while the present invention has been described with reference to multiple embodiments using one or more types of coin-sensing, coin-counting and coin-discriminating techniques, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the present invention. For example, the previously described coin sensor/discriminators may be used in sorting heads designed to discharge various numbers of denominations, including sorting heads designed to discharge three denominations (FIG. 38) and sorting heads designed to discharge six denominations (FIG. 38). Each of these embodiments and obvious variations thereof is contemplated as falling within the spirit and scope of the claimed invention, which is set forth in the following claims.

What is claimed is:

1. A coin sorter, comprising:

a rotatable disc;

a drive motor for rotating said disc;

a stationary sorting head having a lower surface generally parallel to the upper surface of said rotatable disc and spaced slightly therefrom, said lower surface of said sorting head forming a plurality of exit channels for guiding coins of different denominations to different exit locations around the periphery of said disc; and

a shunting mechanism, disposed outside the periphery of said disc, for receiving the coins guided to one of said exit locations and separating the received coins into two or more batches, said shunting mechanism including an exit conduit and at least one internal partition dividing said exit conduit into a plurality of channels, said internal partition being movable between a plurality of positions to guide the coins into different ones of said plurality of channels.

2. The coin sorter of claim 1, wherein an upstream end of said internal partition is movable parallel to the plane of the coins received by said shunting mechanism.

3. The coin sorter of claim 1, wherein said internal partition is movable perpendicular to the plane of the coins received by said shunting mechanism.

4. The coin sorter of claim 1, further including a drive mechanism, disposed between said one of said exit locations and said shunting mechanism, for increasing the physical separation between the coins exiting from said one of said exit locations.

5. The coin sorter of claim 4, wherein said drive mechanism includes a rotating wheel positioned above a stationary smooth surface.

6. The coin sorter of claim 1, wherein said shunting mechanism includes an exit chute and a stationary internal partition dividing said exit chute into a pair of slots, said shunting mechanism further including a pair of pneumatic pumps disposed opposite one another and adjacent an upstream end of said exit chute such that the coins received by said shunting mechanism pass being said pair of pneumatic pumps and into said exit chute, said pair of pneumatic pumps being operable to expel air toward the coins while the coins pass between said pair of pneumatic pumps so as to divert the coins into one of said pair of slots.

7. The coin sorter of claim 6, wherein one of said pair of pneumatic pumps operates to divert the coins to one of said pair of slots, and the other of said pair of pneumatic pumps operates to divert the coins to the other of said pair of slots.

8. The coin sorter of claim 1, wherein said shunting mechanism includes a stationary

surface having an exit slot formed in said surface, a diverter disposed upstream from said exit slot, and a driving mechanism for moving the coins along the stationary surface, said diverter being operable to divert the coins into said exit slot.

9. The coin sorter of claim 8, wherein said diverter is a rotatable pin mounted in said stationary surface and having an elevated section extending upwardly from said stationary surface.

10. The coin sorter of claim 8, wherein said diverter is a pin mounted in said stationary surface and movable between a retracted position and an extended position, said pin being substantially flush with said stationary surface in said retracted position and said pin extending upwardly from said stationary surface in said extended position.

11. The coin sorter of claim 8, wherein said stationary surface includes an elevated strip section having an edge against which the coins bear while received by said shunting mechanism, and wherein said diverter is laterally extendable through said elevated strip section and beyond said edge so as to divert the coins into said exit slot.

12. The coin sorter of claim 8, wherein said exit slot is an exit channel having a lower surface and a gauging wall, said exit channel diverting coins in substantially the same plane as the coins received by said shunting mechanism.

13. The coin sorter of claim 8, wherein said exit slot is an aperture into which diverted coins fall downwardly.

14. The coin sorter of claim 1, wherein said shunting mechanism includes a stationary surface having an exit slot formed in said surface, a diverter disposed upstream from said exit slot, and a driving mechanism for moving the coins along the stationary surface, said diverter being operable to divert the coins to bypass said exit slot.

15. The coin sorter of claim 14, wherein said diverter is a rotatable pin mounted in said stationary surface and having an elevated section extending upwardly from said stationary surface.

16. The coin sorter of claim 14, wherein said diverter is a pin mounted in said stationary surface and movable between a retracted position and an extended position, said pin being substantially flush with said stationary surface in said retracted position and said pin extending upwardly from said stationary surface in said extended position.

17. The coin sorter of claim 14, wherein said stationary surface includes an elevated strip section having an edge against which the coins bear while received by said shunting mechanism, and wherein said diverter is laterally extendable through said elevated strip section and beyond said edge so as to divert the coins to bypass said exit slot.

18. The coin sorter of claim 14, wherein said exit slot is an exit channel having a lower surface and a gauging wall, said exit channel diverting coins in substantially the same plane as the coins received by said shunting mechanism.

19. The coin sorter of claim 14, wherein said exit slot is an aperture into which nondiverted coins fall downwardly.

20. The coin sorter of claim 1, further including a coin discriminator, mounted in said stationary sorting head over said rotatable disc, for discriminating between valid and invalid coins guided to said one of said exit locations.

21. The coin sorter of claim 20, wherein said shunting mechanism, responsive to said coin discriminator, is operable to separate the valid and invalid coins guided to said one of said exit locations.

22. The coin sorter of claim 1, further including a coin discriminator, disposed outside the periphery of said disc between the periphery of said disc and said shunting device, for discriminating between valid and invalid coins guided to said one of said exit locations.

23. The coin sorter of claim 22, wherein said shunting mechanism, responsive to said coin discriminator, is operable to separate the valid and invalid coins guided to said one of said exit locations.

24. The coin sorter of claim 1, further including a counting station along the lower surface of said sorting head, for separately counting each coin denomination.

25. The coin sorter of claim 24, further including means for detecting when a prescribed number of coins guided to said one of said exit locations have been counted, and in response thereto actuating said shunting mechanism.

26. The coin sorter of claim 1, further including a counting station, disposed outside the periphery of said disc between the periphery of said disc and said shunting device, for counting coins exiting from said one of said exit locations.

27. The coin sorter of claim 26, further including means for detecting when a prescribed number of coins passing said counting station have been counted, and in response thereto actuating said shunting mechanism.

28. A coin sorter, comprising:

a rotatable disc;

a drive motor for rotating said disc;

a stationary sorting head having a lower surface generally parallel to the upper surface of said rotatable disc and spaced slightly therefrom, said lower surface of said sorting head forming a plurality of exit channels for guiding coins of different denominations to

different exit locations around the periphery of said disc; and

a plurality of shunting mechanisms, disposed outside the periphery of said disc, for receiving the coins guided to each of said exit locations and separating the received coins into two or more batches, each of said shunting mechanisms including an exit conduit and at least one internal partition dividing said exit conduit into a plurality of channels, said internal partition being movable between a plurality of positions to guide the coins into different ones of said plurality of channels.

29. The coin sorter of claim 28, further including a plurality of drive mechanisms, disposed between said exit locations and each of said shunting mechanisms, for increasing the physical separation between the coins exiting from said exit locations.

30. The coin sorter of claim 28, wherein each of said shunting mechanisms includes a stationary surface having an exit slot formed in said surface, a diverter disposed upstream from said exit slot, and a driving mechanism for moving the coins along the stationary surface, said diverter being operable to divert the coins into said exit slot.

31. The coin sorter of claim 28, wherein each of said shunting mechanisms includes a stationary surface having an exit slot formed in said surface, a diverter disposed upstream from said exit slot, and a driving mechanism for moving the coins along the stationary surface, said diverter being operable to divert the coins to bypass said exit slot.

32. The coin sorter of claim 28, further including a plurality of coin discriminators, mounted in said stationary sorting head over said rotatable disc, for discriminating between valid and invalid coins guided to each of said exit locations.

33. The coin sorter of claim 32, wherein said plurality of shunting mechanisms, responsive to respective ones of said plurality of coin discriminators, are operable to separate the valid and invalid coins guided to each of said exit locations.

34. The coin sorter of claim 28, further including a plurality of coin discriminators, disposed outside the periphery of said disc between the periphery of said disc and said plurality of shunting devices, for discriminating between valid and invalid coins guided to each of said exit locations.

35. The coin sorter of claim 34, wherein said plurality of shunting mechanisms, responsive to respective ones of said plurality of coin discriminators, are operable to separate the valid and invalid coins guided to each of said exit locations.

36. The coin sorter of claim 28, further including one or more counting stations along the lower surface of said sorting head, for separately counting each coin denomination.

37. The coin sorter of claim 36, further including means for detecting when a prescribed

number of coins guided to one of said exit locations have been counted, and in response thereto actuating the shunting mechanism associated with said one of said exit locations.

38. The coin sorter of claim 28, further including a plurality of counting station, disposed outside the periphery of said disc between the periphery of said disc and said plurality of shunting devices, for counting coins exiting from each of said exit locations.

39. The coin sorter of claim 38, further including means for detecting when a prescribed number of coins passing one of said counting stations have been counted, and in response thereto actuating the shunting mechanism associated with said one of said counting stations.

40. A coin sorter, comprising:

a rotatable disc;

a drive motor for rotating said disc;

a stationary sorting head having a lower surface generally parallel to the upper surface of said rotatable disc and spaced slightly therefrom, said lower surface of said sorting head forming a plurality of exit channels for guiding coins of different denominations to different exit locations around the periphery of said disc, at least one of said exit channels including a pair of exit paths; and

a shunting mechanism, mounted in said one of said exit channels, for guiding the coins entering said one of said exit channels downstream through one of said pair of exit paths.

41. The coin sorter of claim 40, wherein said shunting mechanism includes a rotatable pin having an elevated section extending downwardly from the lower surface of said sorting head into said one of said exit channels.

42. The coin sorter of claim 40, wherein said shunting mechanism includes an extendable pin movable between a retracted position and an extended position, said pin being substantially flush with the lower surface of said sorting head in said retracted position and said pin extending downwardly from the lower surface of said sorting head in said extended position.

43. The coin sorter of claim 40, further including a coin discriminator, mounted in said stationary sorting head upstream relative to said shunting device, for discriminating between valid and invalid coins entering said one of said exit channels.

44. The coin sorter of claim 43, wherein said shunting mechanism, responsive to said coin discriminator, is operable to separate the valid and invalid coins entering said one of said exit channels and to guide the valid coins through one of said pair of exit paths and the invalid coins through the other of said pair of exit paths.

45. The coin sorter of claim 40, further including a counting station, disposed along the lower surface of said sorting head upstream relative to said shunting device, for separately counting each coin denomination.

46. The coin sorter of claim 45, further including means for detecting when a prescribed number of coins entering said one of said exit channels have been counted, and in response thereto actuating said shunting mechanism.

47. The coin sorter of claim 1, wherein said internal partition includes a fixed downstream pivot point and an upstream end pivotable about said fixed downstream pivot point.

48. The coin sorter of claim 28, wherein said internal partition includes a fixed downstream pivot point and an upstream end pivotable about said fixed downstream pivot point.

49. A coin sorter, comprising:

a rotatable disc having a resilient top surface;

a drive motor for rotating said disc;

a stationary sorting head having a lower surface generally parallel to said resilient top surface of said rotatable disc and spaced slightly therefrom, said lower surface of said sorting head forming a plurality of exit channels for guiding coins of different denominations to different exit locations around the periphery of said disc, upper surfaces of at least exit ends of said respective exit channels being positioned sufficiently close to said resilient top surface of said rotatable disc to press the coins down into said resilient top surface as the coins are controllably guided to said exit locations; and

a plurality of shunting means, disposed outside the periphery of said disc adjacent to said respective exit locations, for receiving the coins guided to said exit locations and separating the received coins into two or more batches.

50. A coin sorter for sorting coins of at least one coin denomination from an invalid item not of said at least one coin denomination, the coin sorter comprising:

a rotatable disc having a resilient surface for receiving said coins and imparting rotational movement to said coins;

a stationary sorting head having a contoured surface spaced slightly away from and generally parallel to said resilient surface of said rotatable disc, said stationary sorting head configured and arranged for sorting and discharging said coins of said at least one coin denomination through respective coin denomination exit paths around the periphery of said stationary sorting head and into associated stationary coin-collecting containers; and

a coin discrimination sensor, located between one of the coin denomination exit paths and its associated stationary coin-collecting container, for sensing an invalid item before the invalid item reaches the stationary coin-collecting container associated with said one of the coin denomination exit channels.

51. The coin sorter of claim 50, further including

a diverter located in a coin route between said discimination sensor and the stationary coin-collecting container associated with said one of the coin denomination exit paths; and

a control circuit, responsive to said discrimination sensor sensing an invalid item in the coin route, engaging said diverter to prevent the invalid item from being discharged into the stationary coin-collecting container associated with said one of the coin denomination exit paths.

52. A coin sorter, comprising:

a rotatable disc having a resilient surface for receiving coins of at least one denomination and imparting rotational movement to said coins;

a stationary sorting head having a contoured surface spaced slightly away from and generally parallel to said resilient surface of said rotatable disc, said stationary sorting head configured and arranged for sorting and discharging said coins through respective coin denomination exit paths around the periphery of said stationary sorting head and into associated stationary coin-collecting containers located below the level of said resilient surface of said rotatable disc; and

a shunting mechanism, disposed outside the periphery of said disc in a coin route between one of the coin denomination exit paths and its associated stationary coin-collecting container, for receiving the coins discharged from said one of said exit paths, said shunting mechanism including a diverting member separating the received coins into two or more batches while always maintaining the coins at or beneath the level of said resilient surface of said rotatable disc such that the coins are never diverted to a level above the level of said resilient surface of said rotatable disc.

53. A coin sorter, comprising:

a rotatable disc;

a drive motor for rotating said disc;

a stationary sorting head having a lower surface generally parallel to the upper surface of said rotatable disc and spaced slightly therefrom, said lower surface of said sorting head forming a plurality of exit channels having respective downstream ends opening at the periphery of said sorting head, said plurality of exit channels guiding coins of different

denominations to said downstream ends of said exit channels; and

a shunting mechanism for separating the coins guided to one of said exit channels into two or more batches, said shunting mechanism having an upstream end for receiving the coins guided to said one of said exit channels, said upstream end being closely and immediately adjacent the downstream end of said one of said exit channels so that the coins pass directly from the downstream end of said one of said exit channels to said upstream end of said shunting mechanism.

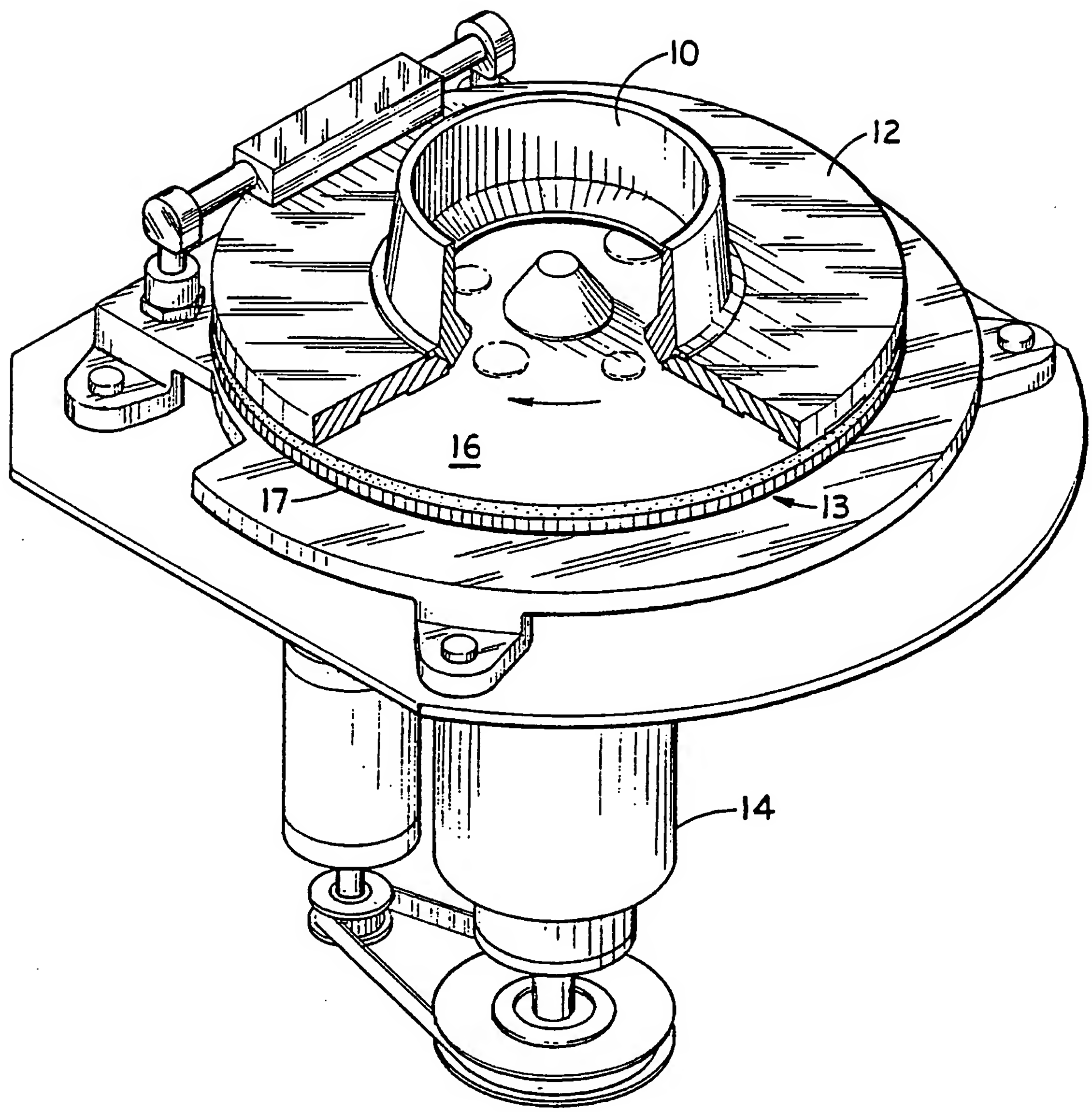


FIG. 1

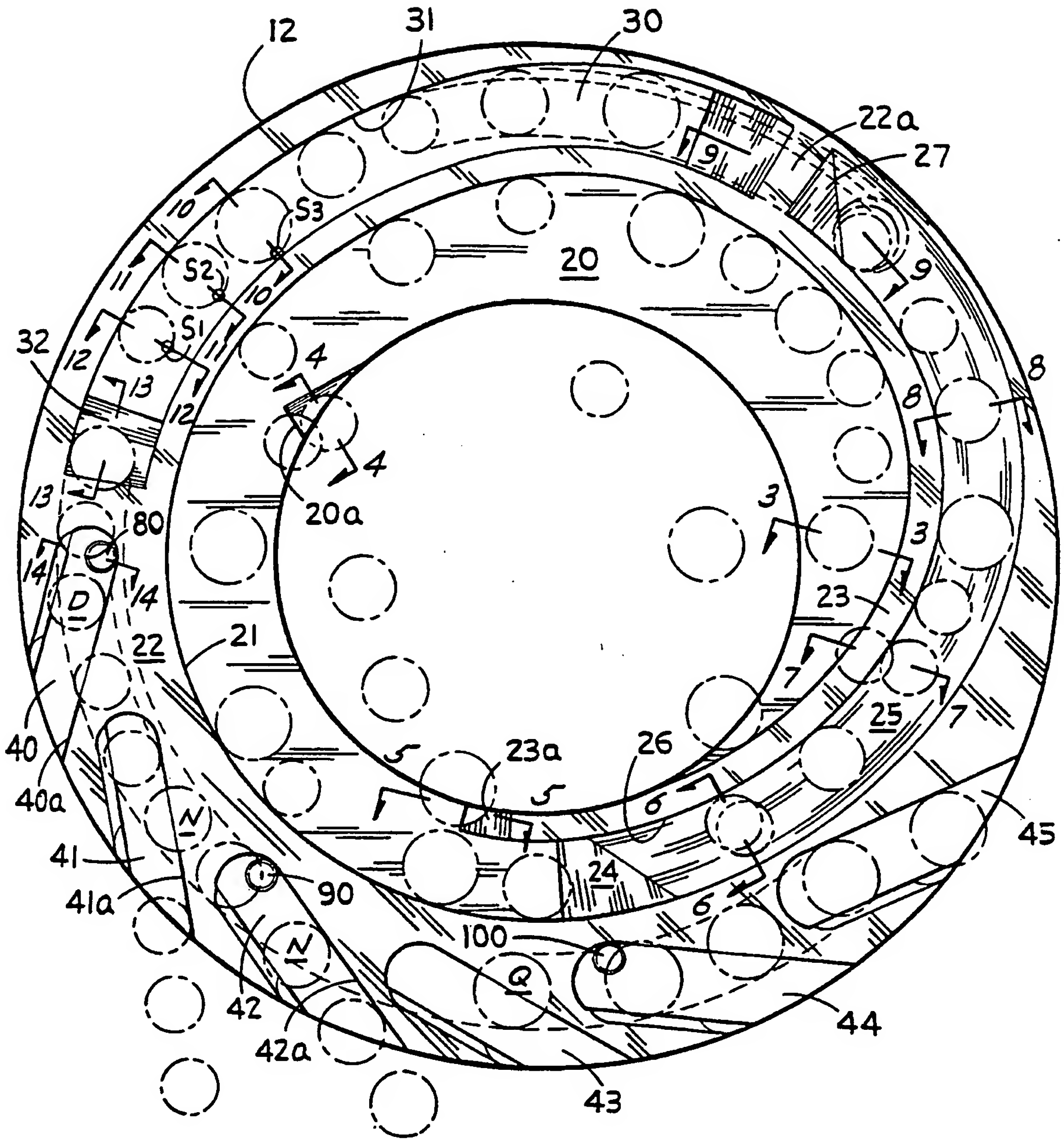

12
31
30
22a
27
9
10
S3
S2
20
S1
32
12
13
4
8
20a
3
180
14
D
23
22
21
7
25
40
40a
5
23a
26
6
N
41
41a
90
24
45
100
Q
42
42a
44
43

FIG. 2

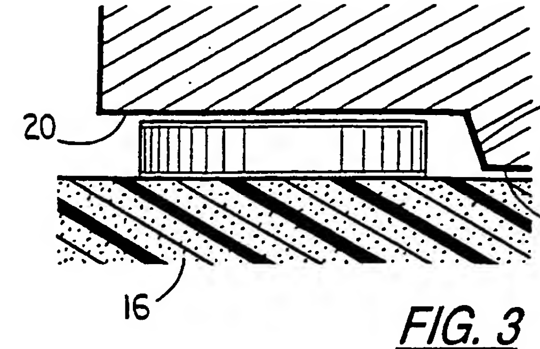


FIG. 3

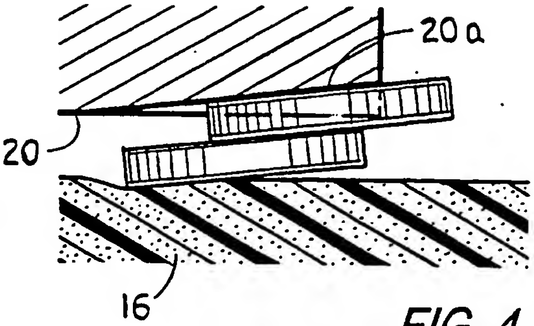


FIG. 4

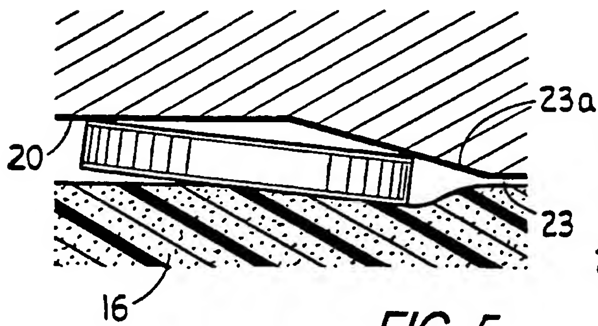


FIG. 5

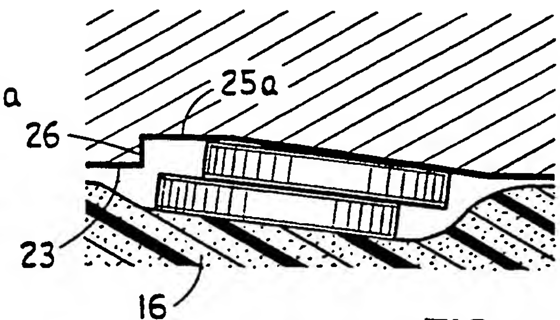


FIG. 6

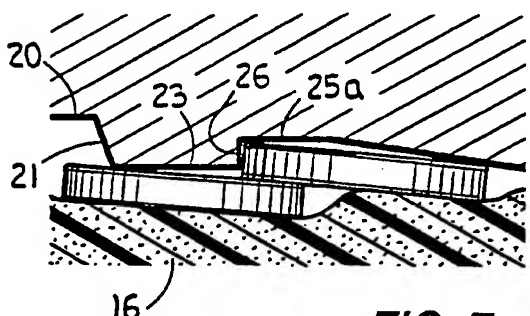


FIG. 7

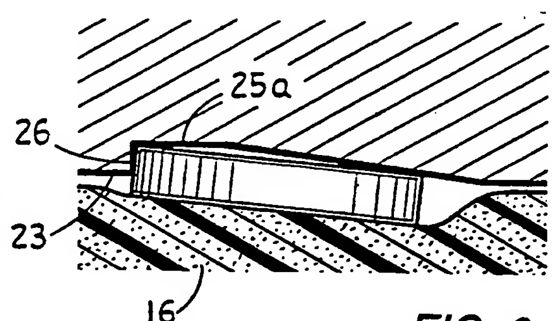


FIG. 8

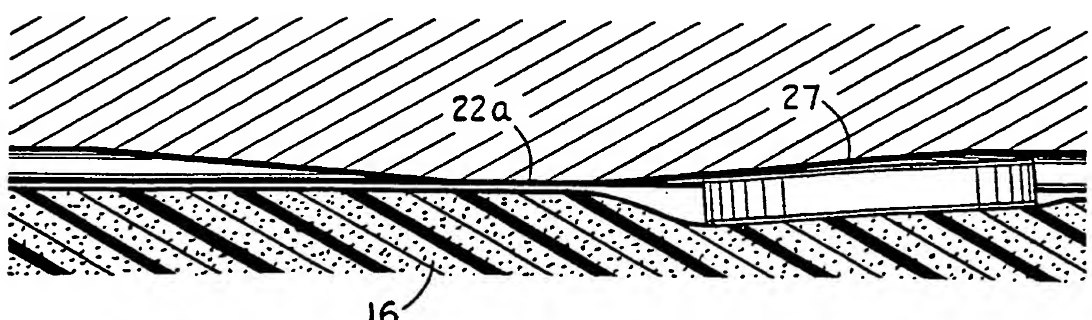


FIG. 9

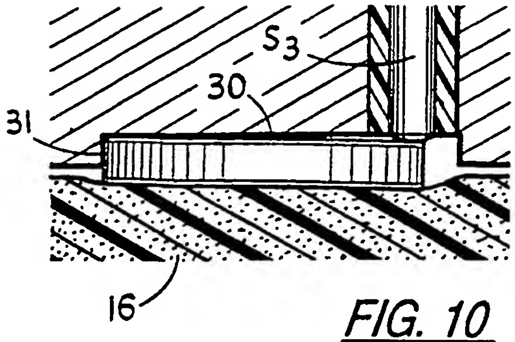


FIG. 10

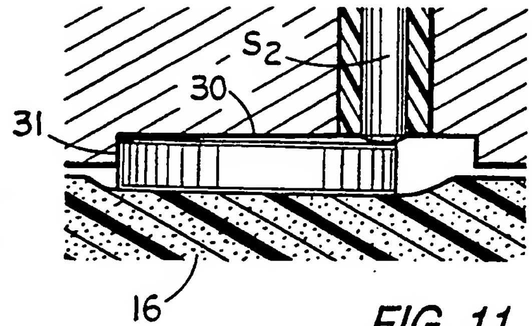


FIG. 11

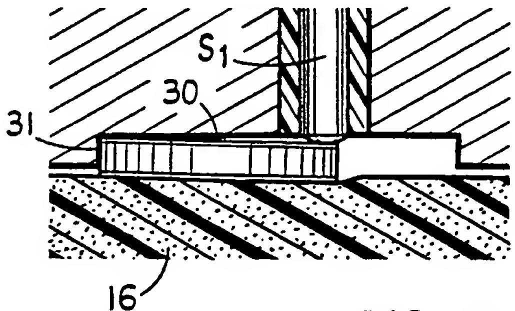


FIG. 12

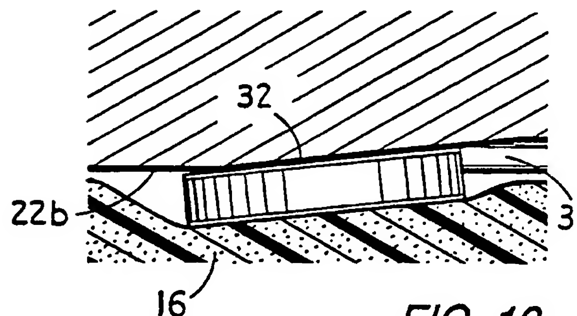


FIG. 13

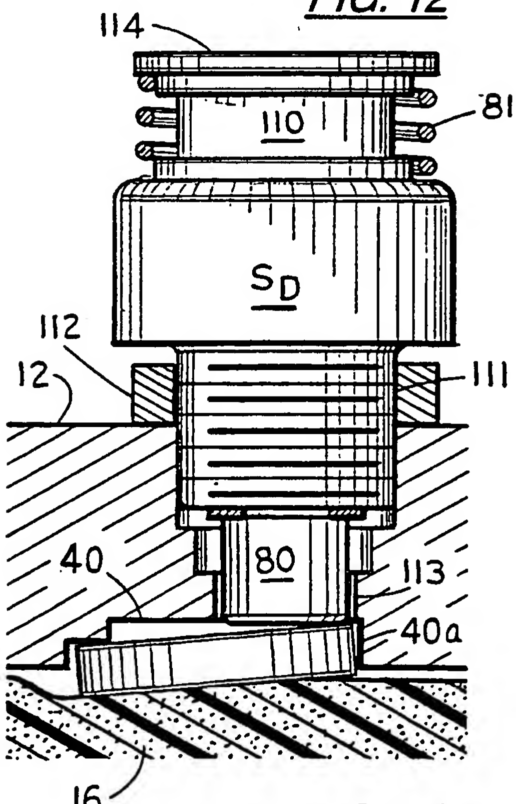


FIG. 14

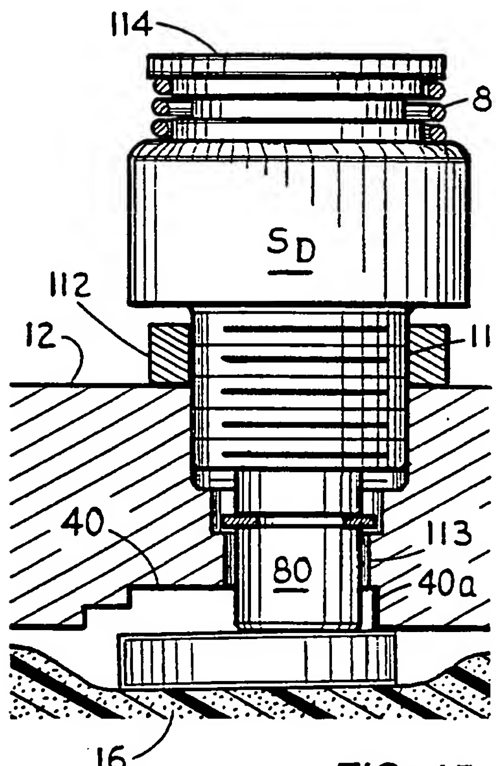


FIG. 15

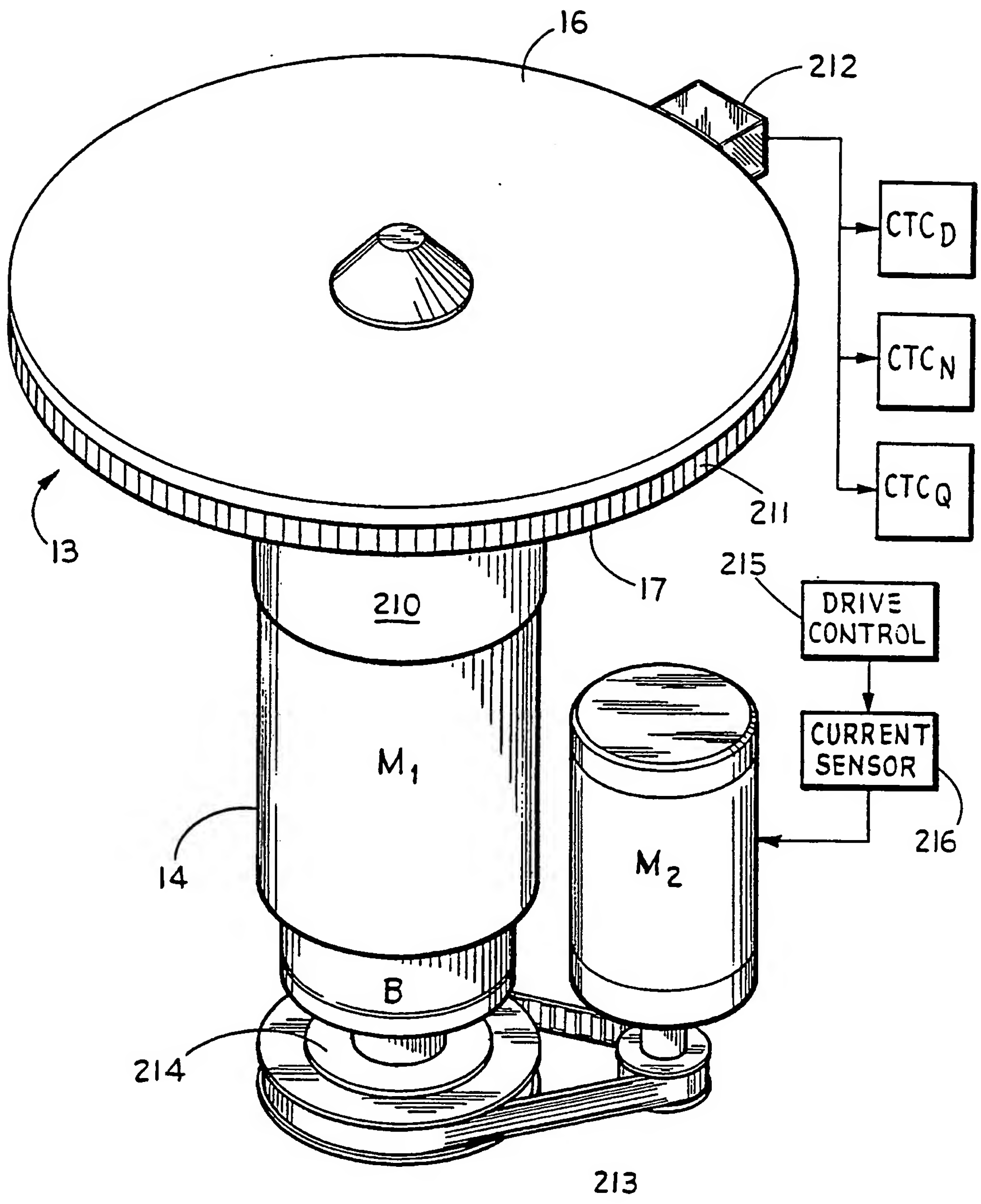

16
212
CTC D
CTC N
CTC Q
211
13
17
215
DRIVE CONTROL
210
CURRENT SENSOR
M 1
216
14
M 2
B
214
213

FIG. 16

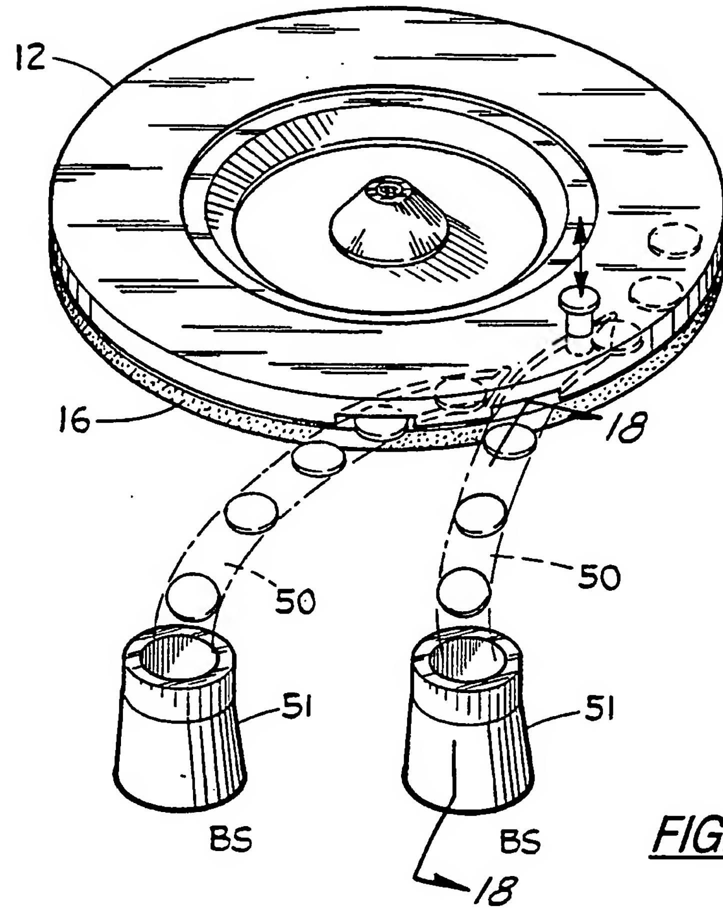


FIG. 17

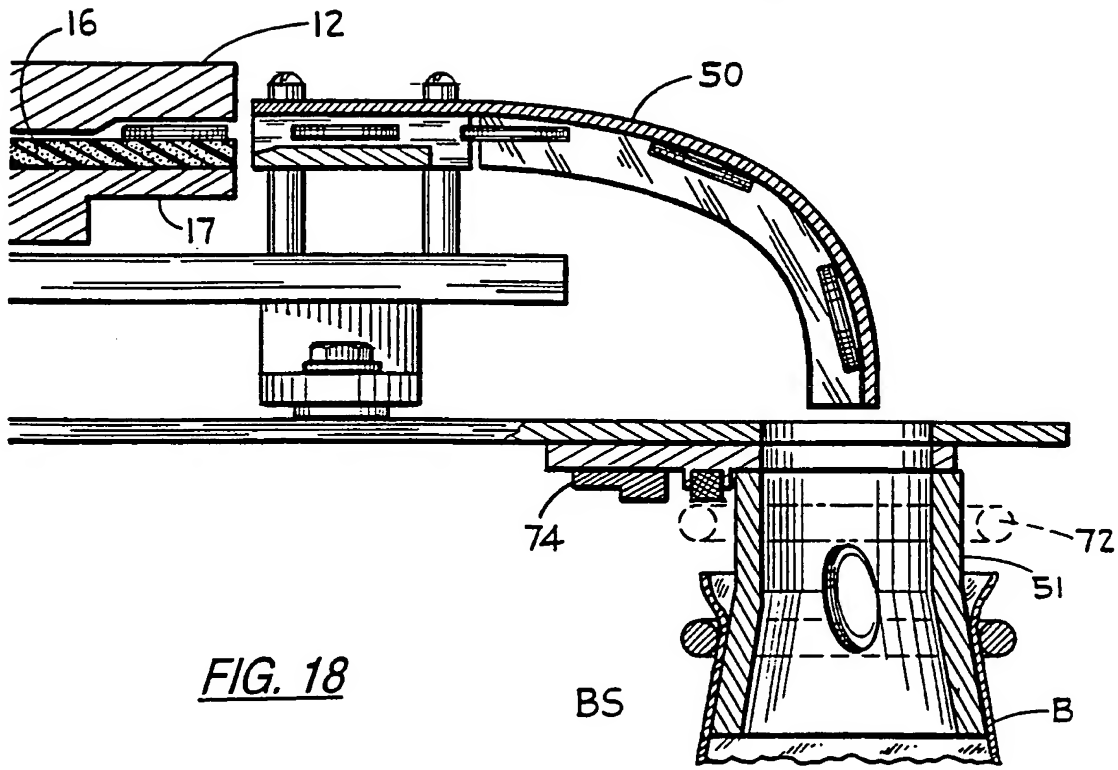


FIG. 18

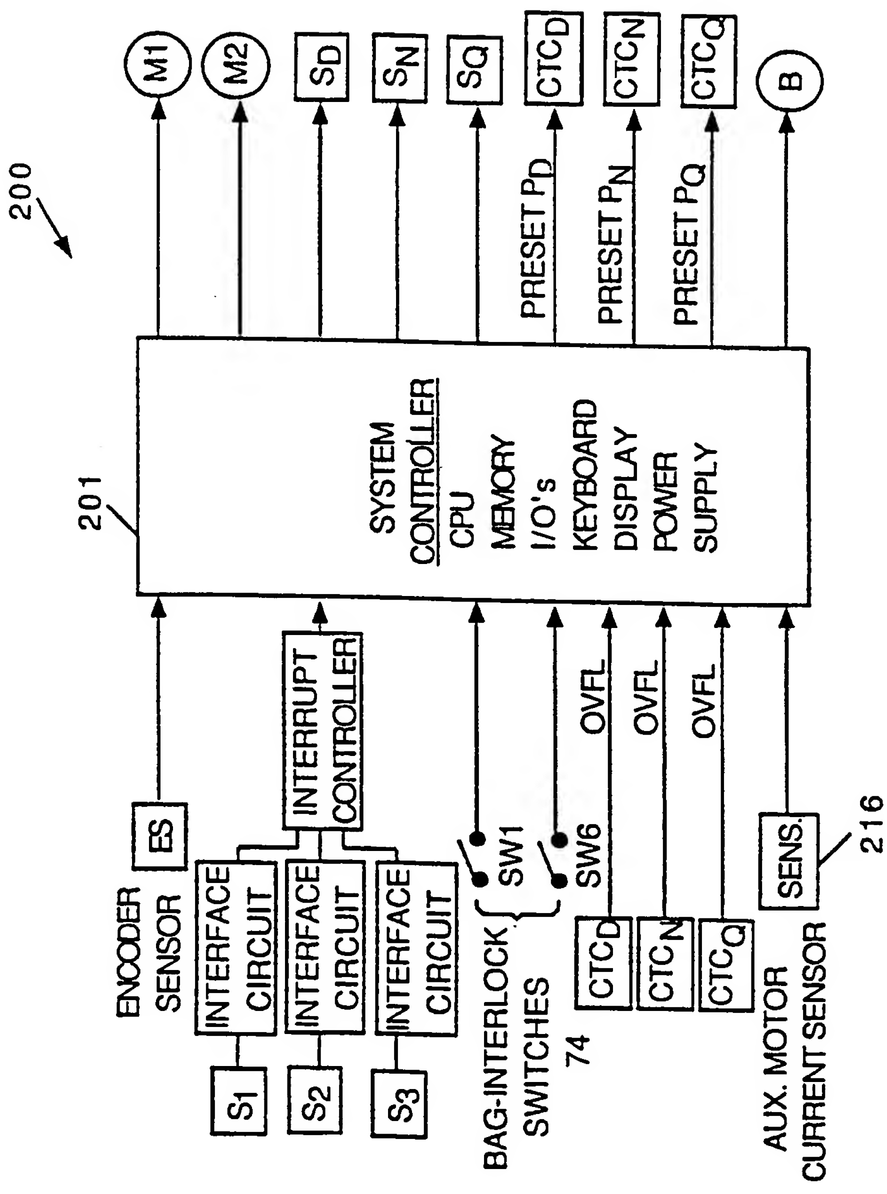

200
201
SYSTEM CONTROLLER
CPU
MEMORY
I/O's
KEYBOARD
DISPLAY
POWER SUPPLY
M1
M2
S_D
S_N
S_Q
CTC_D
CTC_N
CTC_Q
B
PRESET P_D
PRESET P_N
PRESET P_Q
ENCODER SENSOR
ES
INTERRUPT CONTROLLER
INTERFACE CIRCUIT
INTERFACE CIRCUIT
INTERFACE CIRCUIT
S_1
S_2
S_3
SW1
SW6
BAG-INTERLOCK SWITCHES
74
OVFL
OVFL
OVFL
CTC_D
CTC_N
CTC_Q
SENS.
216
AUX. MOTOR CURRENT SENSOR

FIG. 19

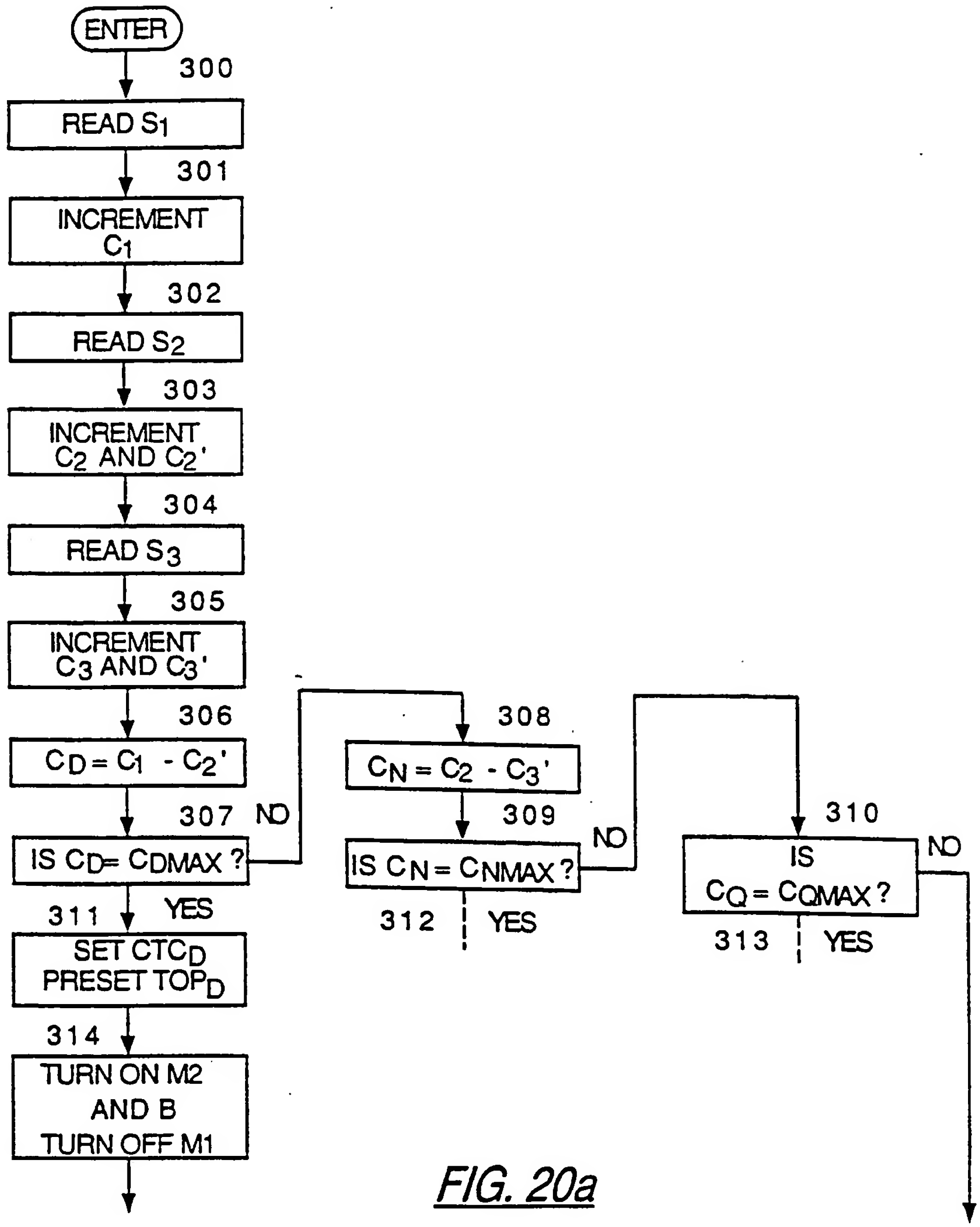

ENTER
300
READ S1
301
INCREMENT C1
302
READ S2
303
INCREMENT C2 AND C2'
304
READ S3
305
INCREMENT C3 AND C3'
306
CD = C1 - C2'
307
IS CD= CDMAX ?
NO
YES
311
SET CTCD PRESET TOPD
314
TURN ON M2 AND B TURN OFF M1
308
CN = C2 - C3'
309
IS CN = CNMAX ?
NO
312
YES
310
IS CQ = CQMAX ?
NO
313
YES

FIG. 20a

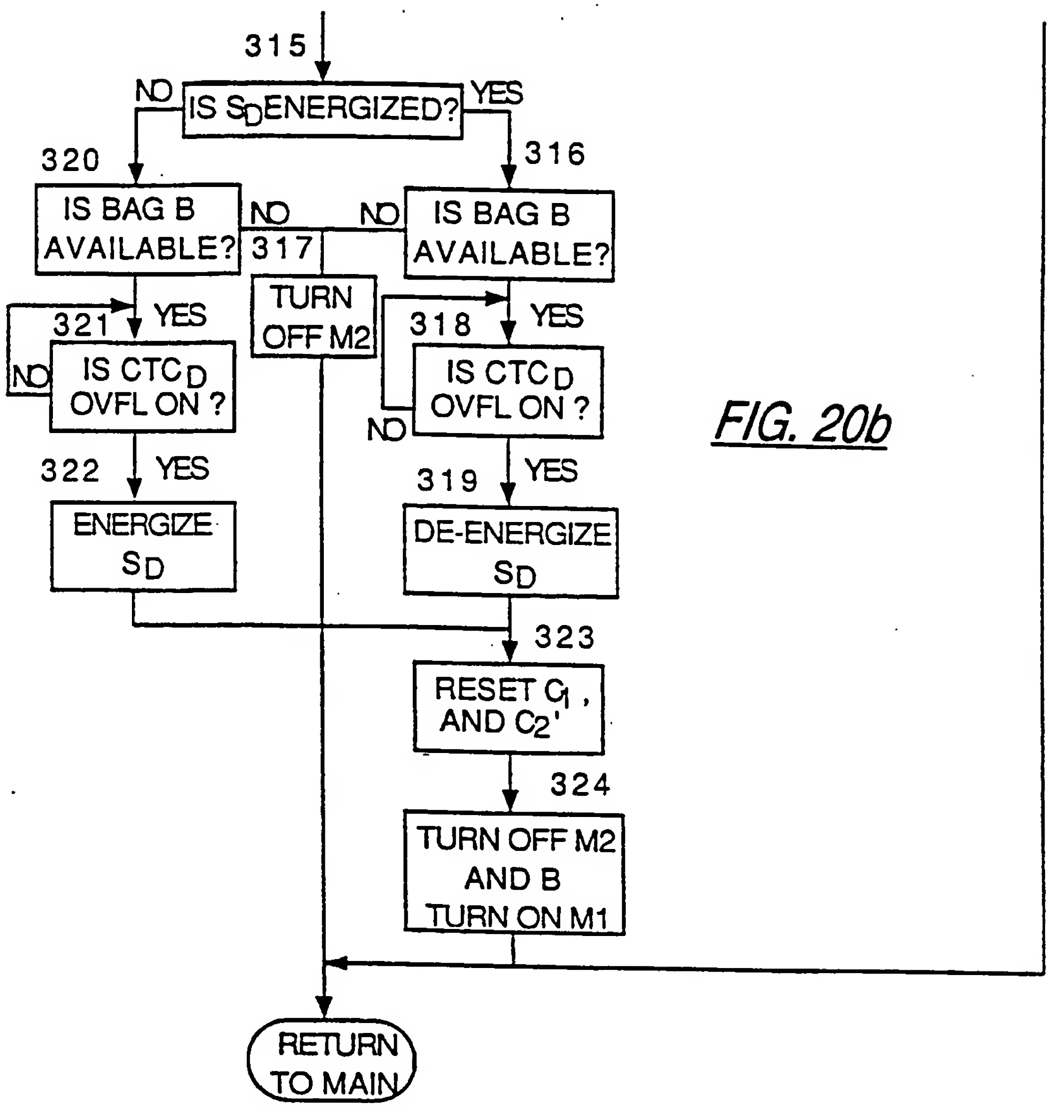

315
NO
IS S_D ENERGIZED?
YES
320
316
IS BAG B AVAILABLE?
NO
NO
IS BAG B AVAILABLE?
317
TURN OFF M2
321
YES
318
YES
NO
IS CTC_D OVFL ON ?
IS CTC_D OVFL ON ?
NO
322
YES
319
YES
ENERGIZE S_D
DE-ENERGIZE S_D
323
RESET C_1, AND C_2'
324
TURN OFF M2 AND B TURN ON M1
RETURN TO MAIN

FIG. 20b

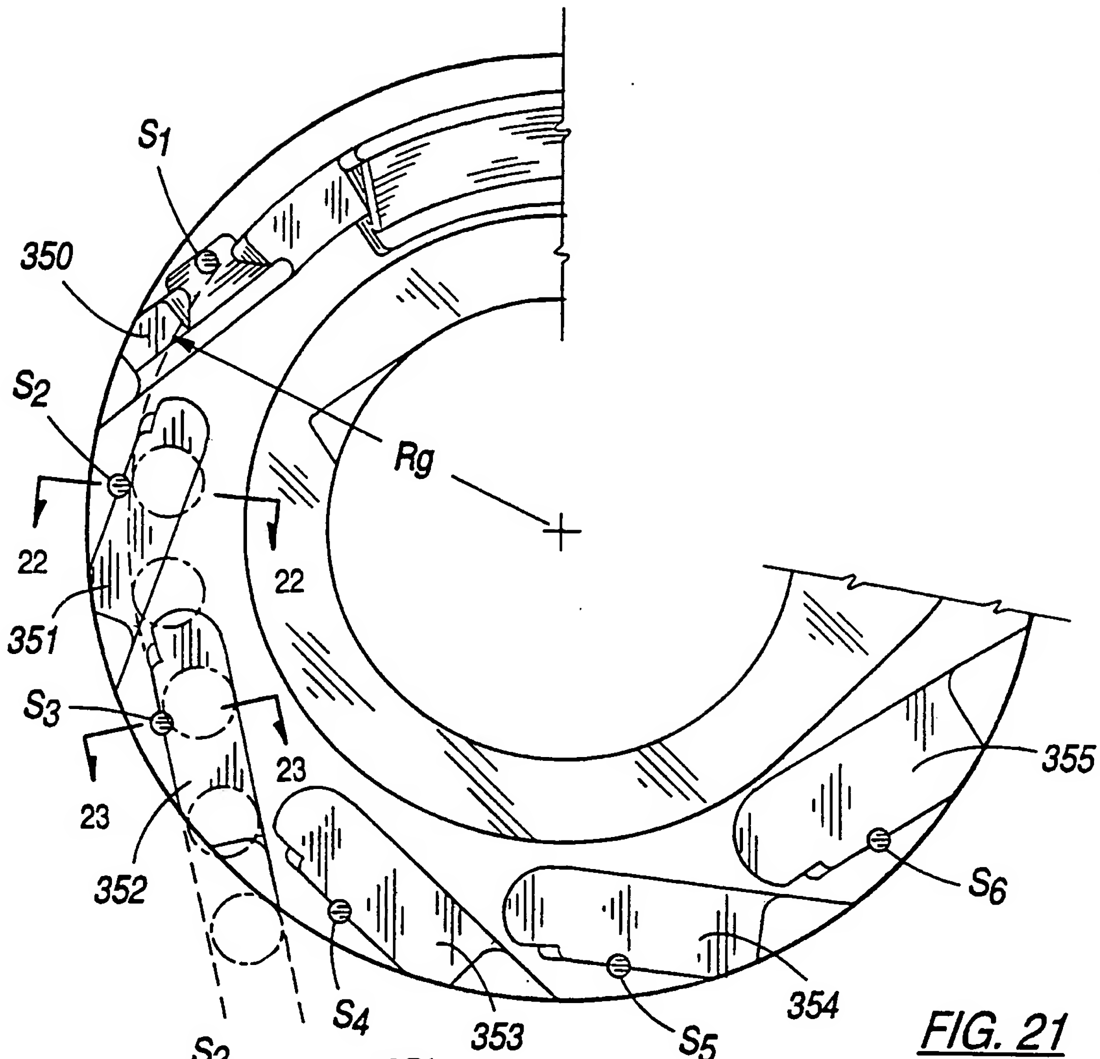


FIG. 21

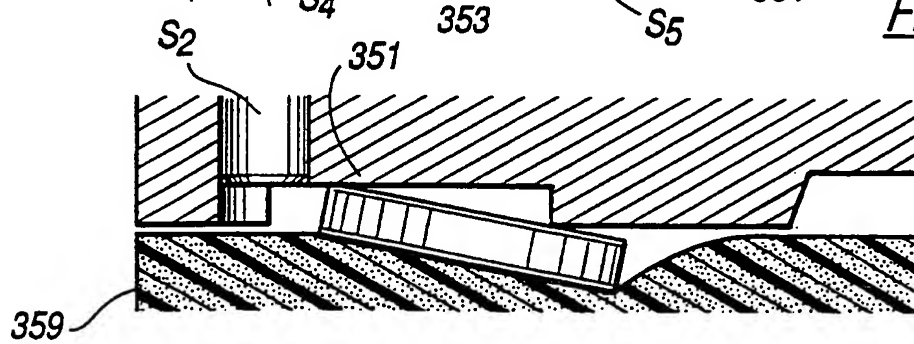


FIG. 22

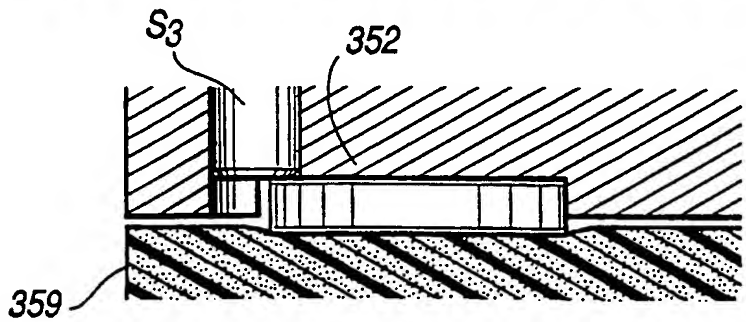


FIG. 23

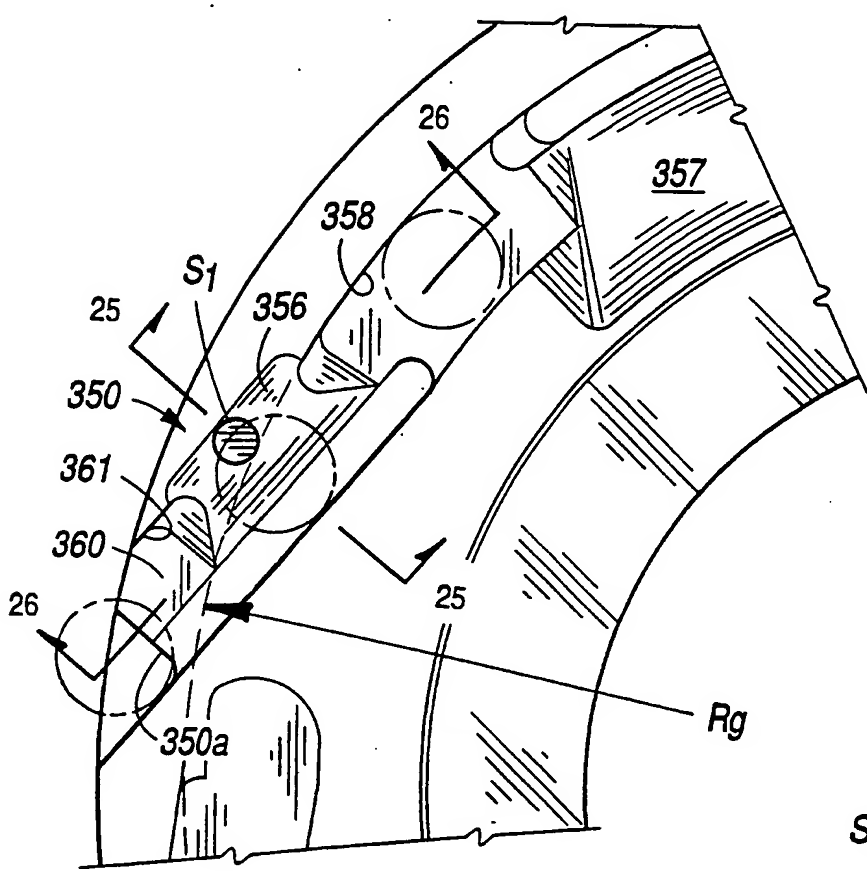


FIG. 24

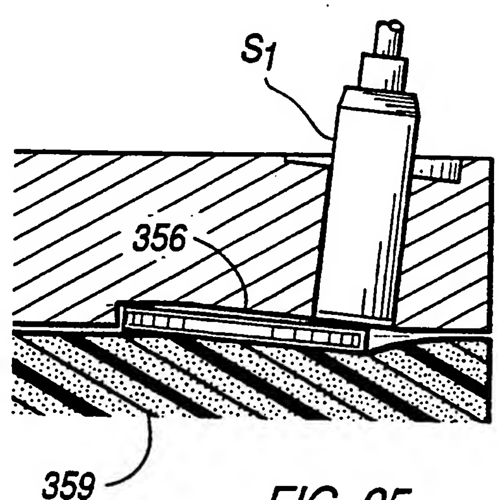


FIG. 25

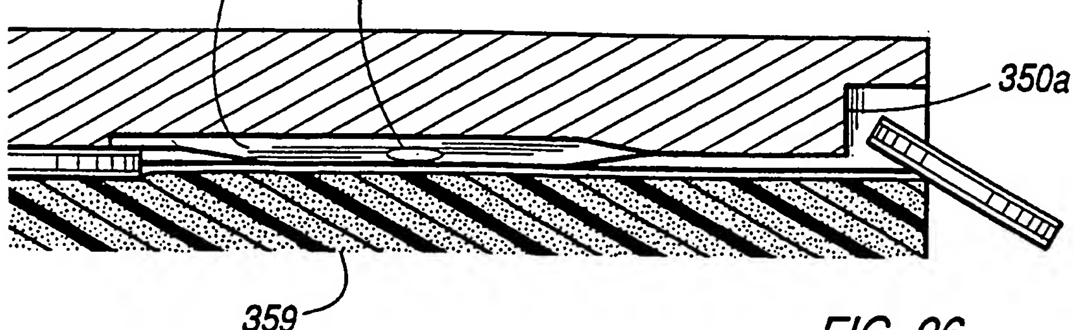
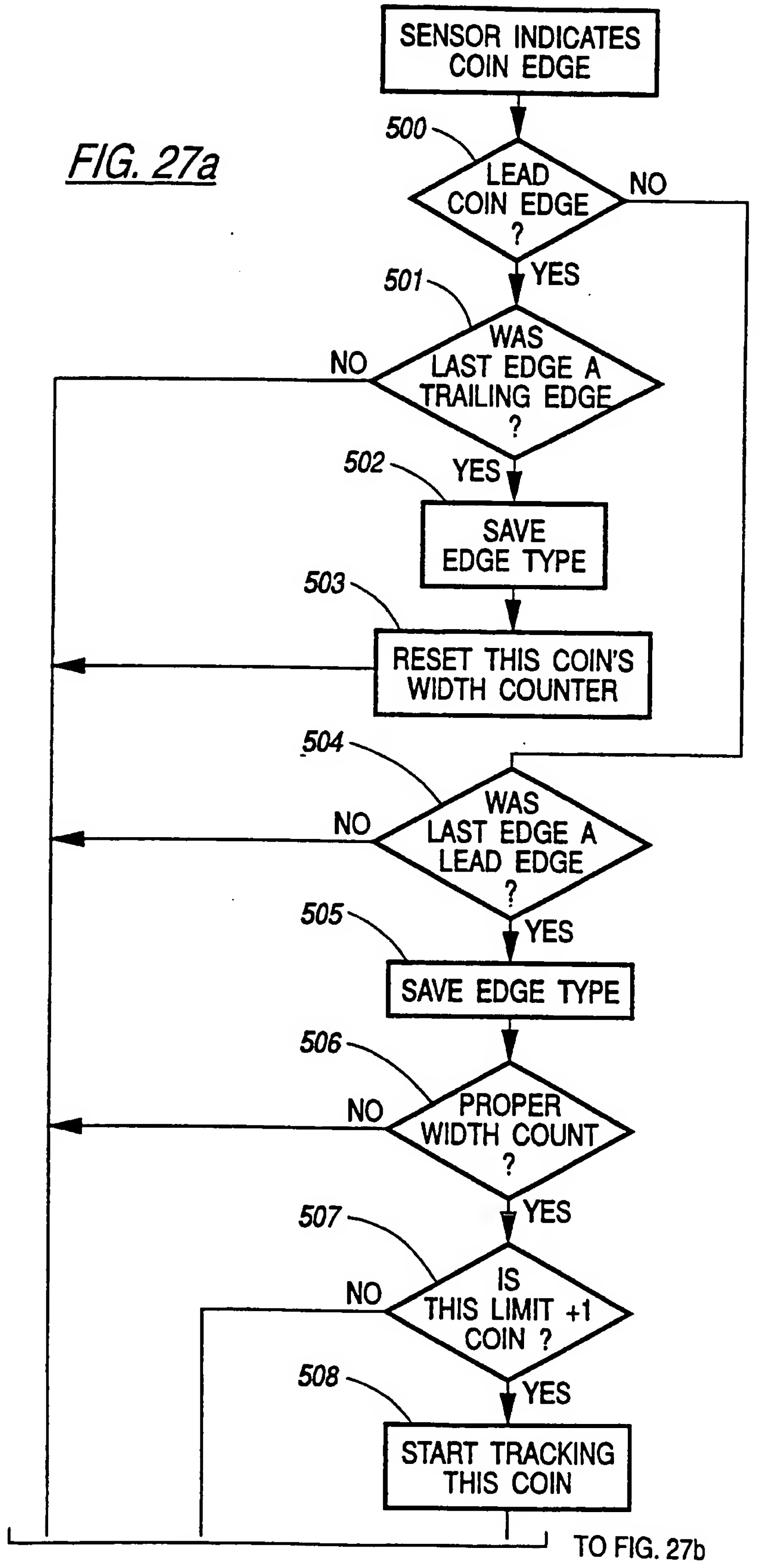


FIG. 26

FIG. 27a


SENSOR INDICATES COIN EDGE
500
LEAD COIN EDGE ?
NO
YES
501
WAS LAST EDGE A TRAILING EDGE ?
NO
YES
502
SAVE EDGE TYPE
503
RESET THIS COIN'S WIDTH COUNTER
504
WAS LAST EDGE A LEAD EDGE ?
NO
YES
505
SAVE EDGE TYPE
506
PROPER WIDTH COUNT ?
NO
YES
507
IS THIS LIMIT +1 COIN ?
NO
YES
508
START TRACKING THIS COIN
TO FIG. 27b

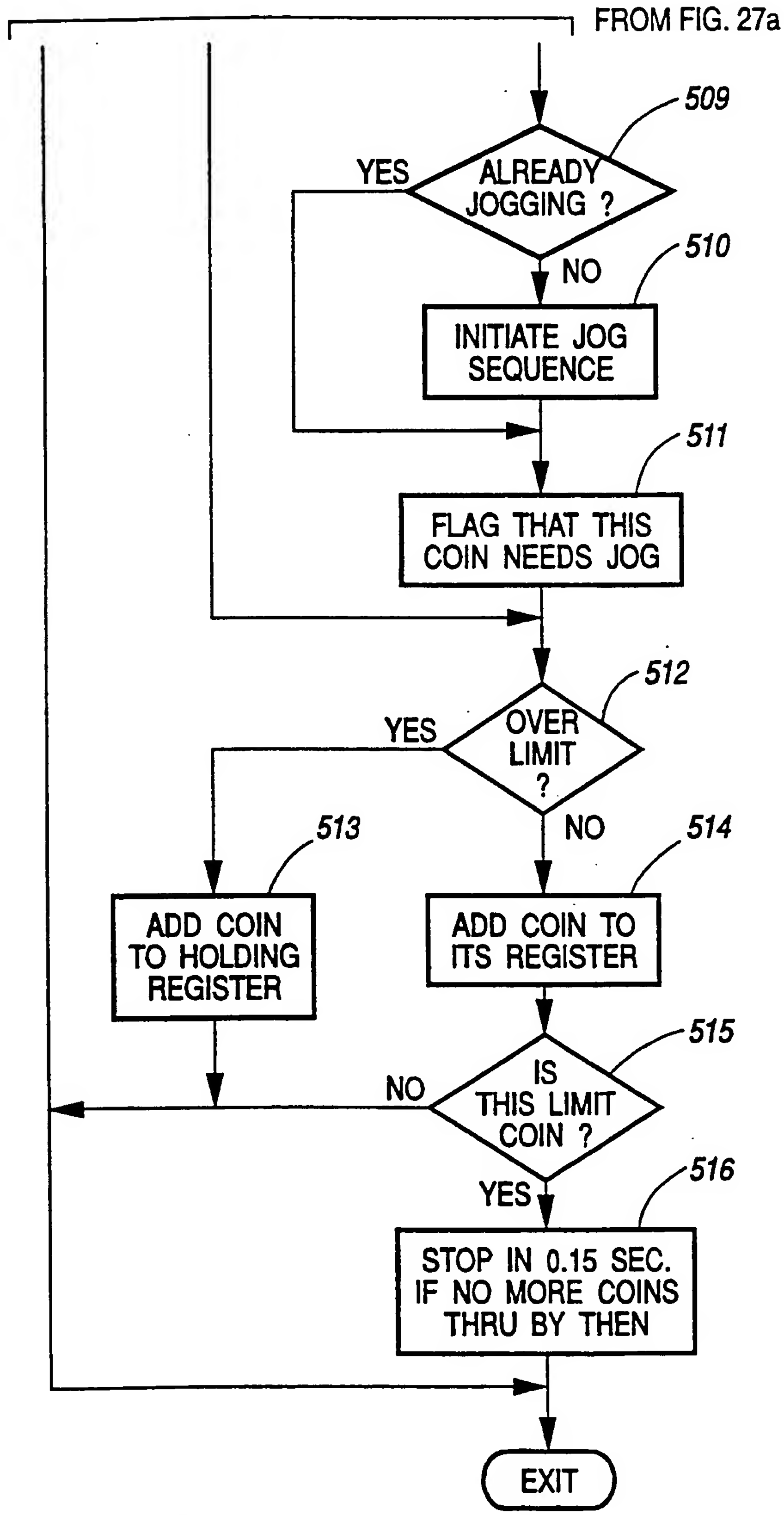
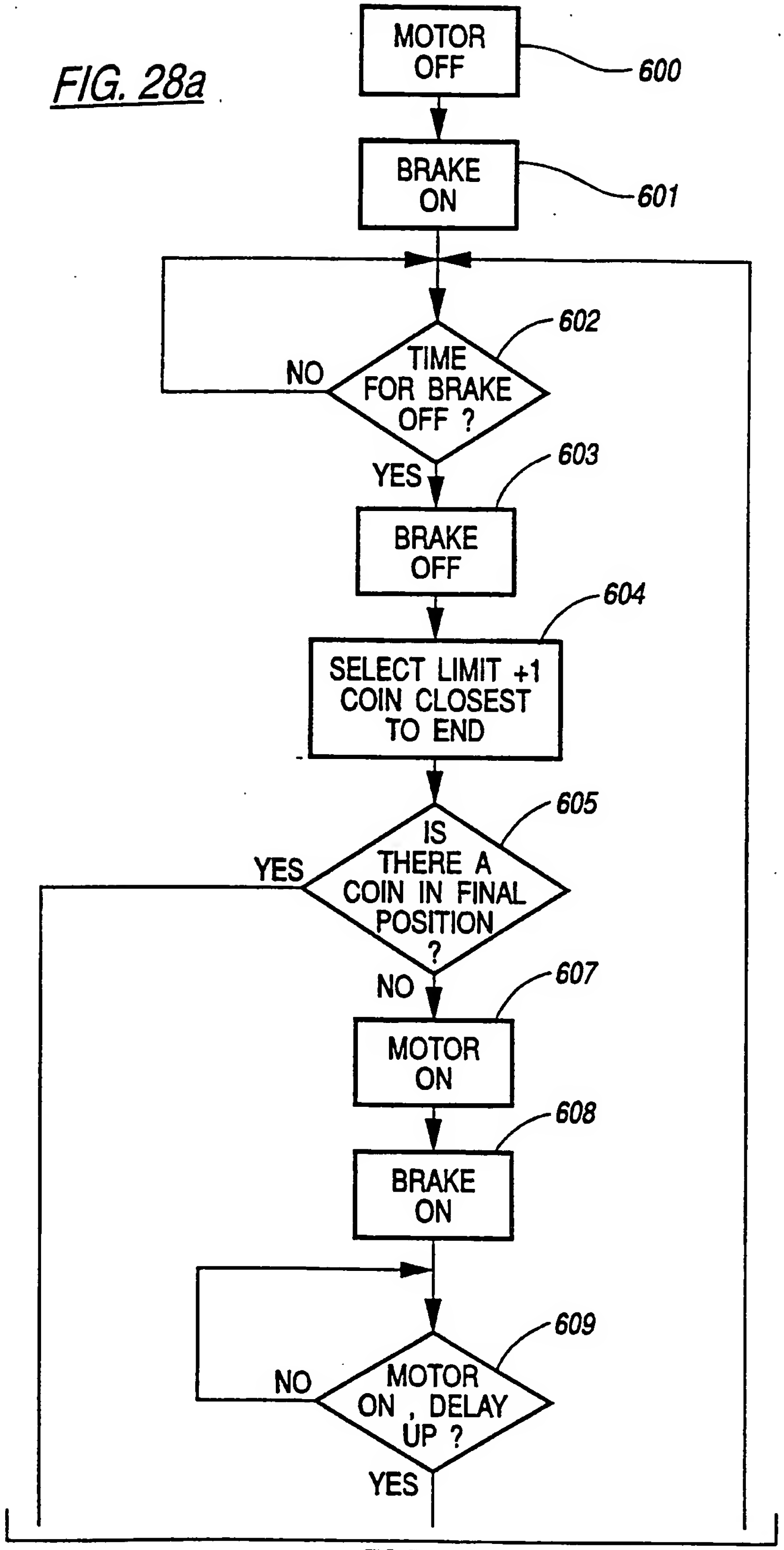

FROM FIG. 27a
509
ALREADY JOGGING ?
YES
NO
510
INITIATE JOG SEQUENCE
511
FLAG THAT THIS COIN NEEDS JOG
512
OVER LIMIT ?
YES
NO
513
ADD COIN TO HOLDING REGISTER
514
ADD COIN TO ITS REGISTER
515
IS THIS LIMIT COIN ?
NO
YES
516
STOP IN 0.15 SEC. IF NO MORE COINS THRU BY THEN
EXIT

FIG. 27b

FIG. 28a



TO FIG. 28b

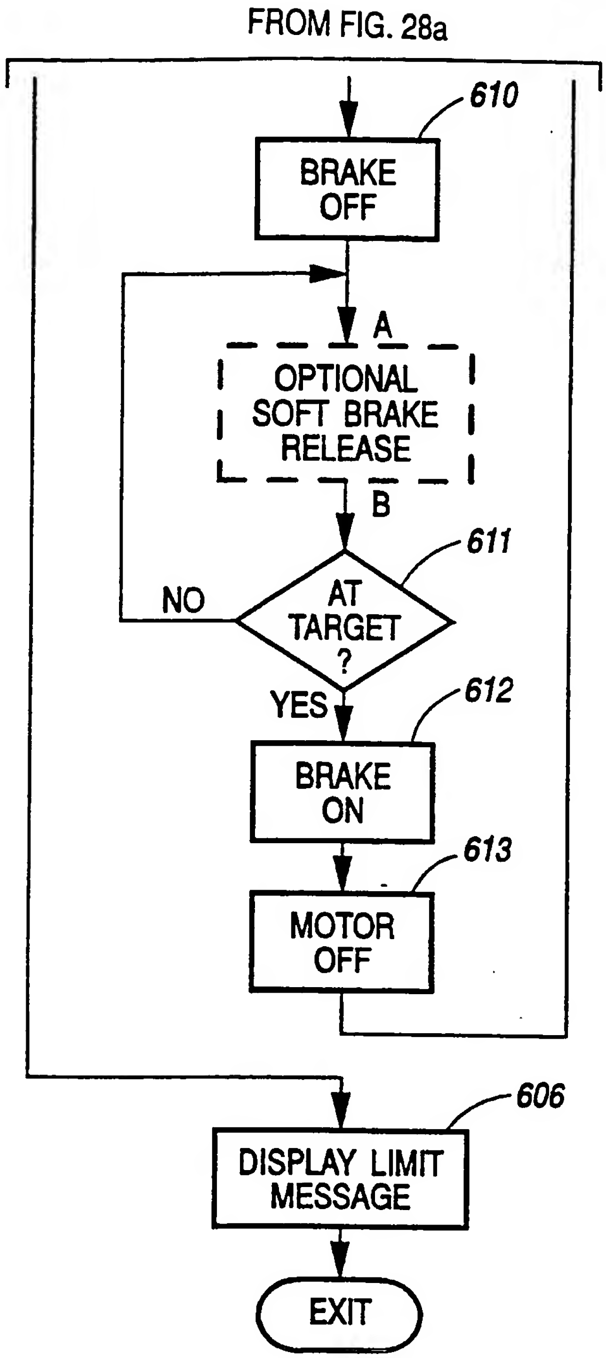


FIG. 28b

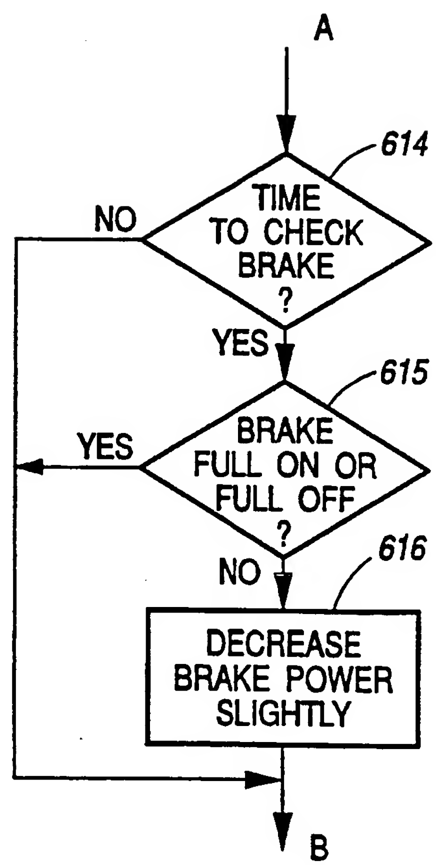
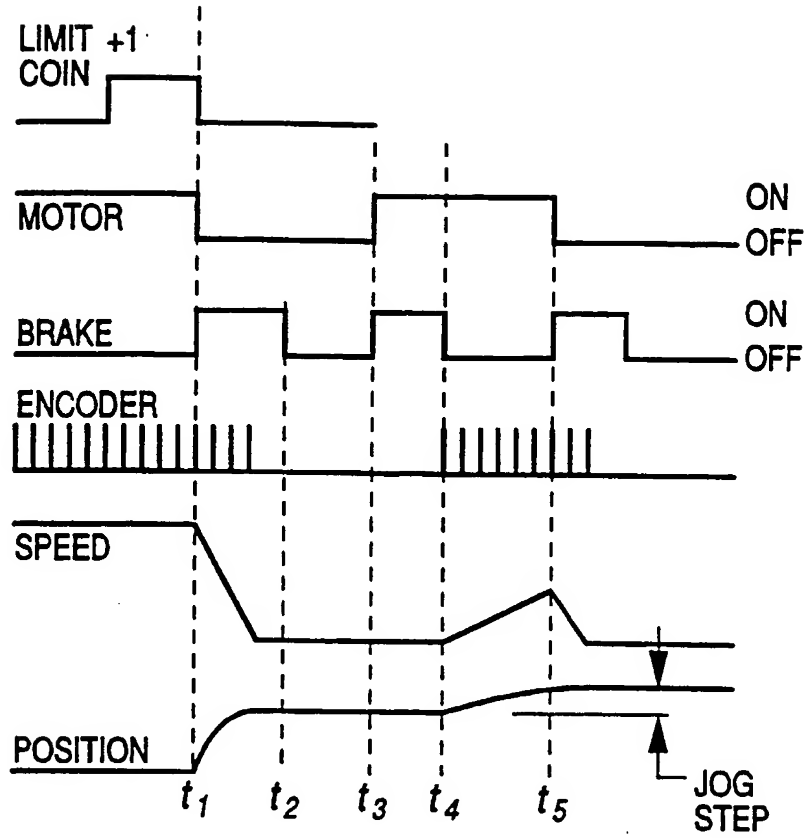
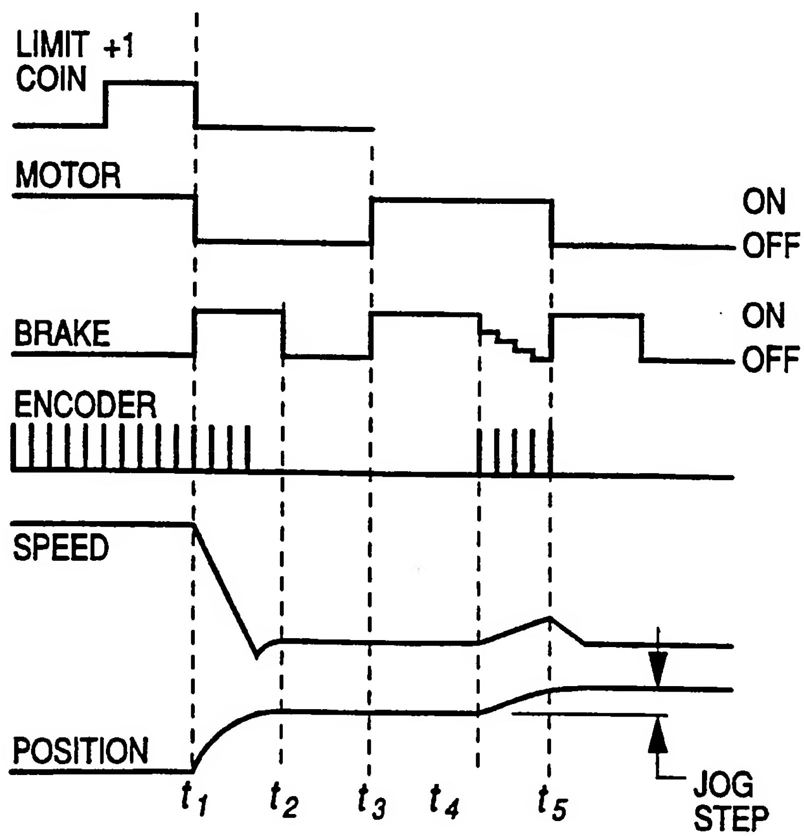


FIG. 29



LIMIT +1
COIN
MOTOR
ON
OFF
BRAKE
ON
OFF
ENCODER
SPEED
POSITION
t_1
t_2
t_3
t_4
t_5
JOG STEP

FIG. 30



LIMIT +1
COIN
MOTOR
ON
OFF
BRAKE
ON
OFF
ENCODER
SPEED
POSITION
t_1
t_2
t_3
t_4
t_5
JOG STEP

FIG. 31

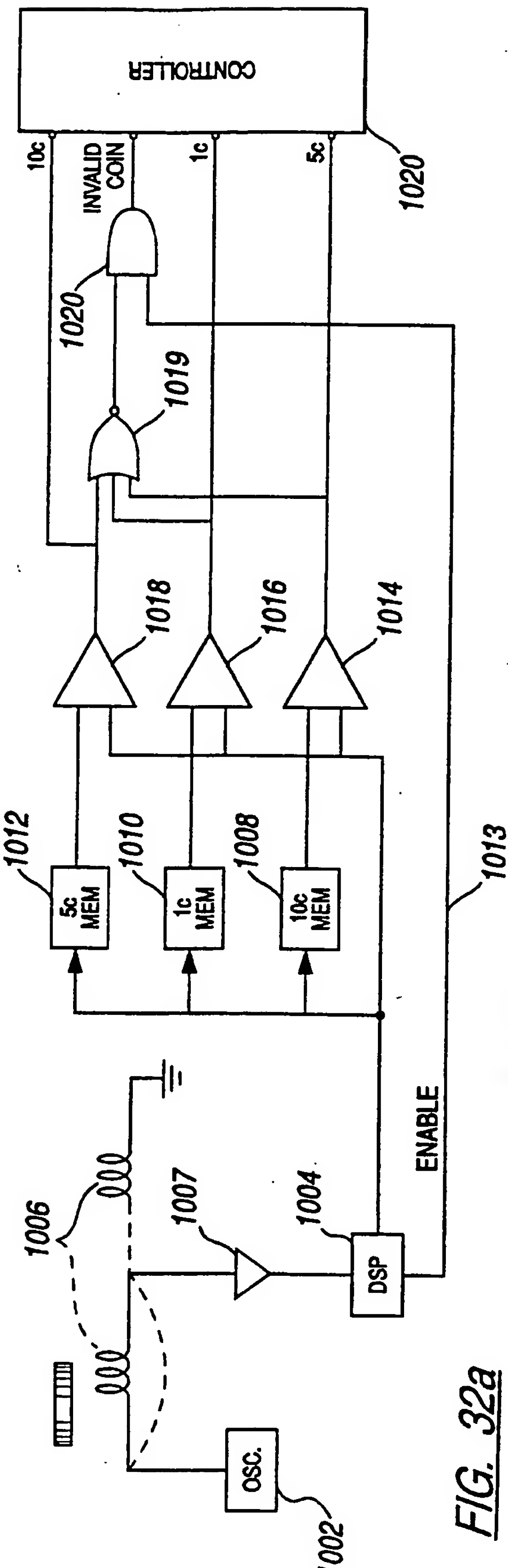


FIG. 32a

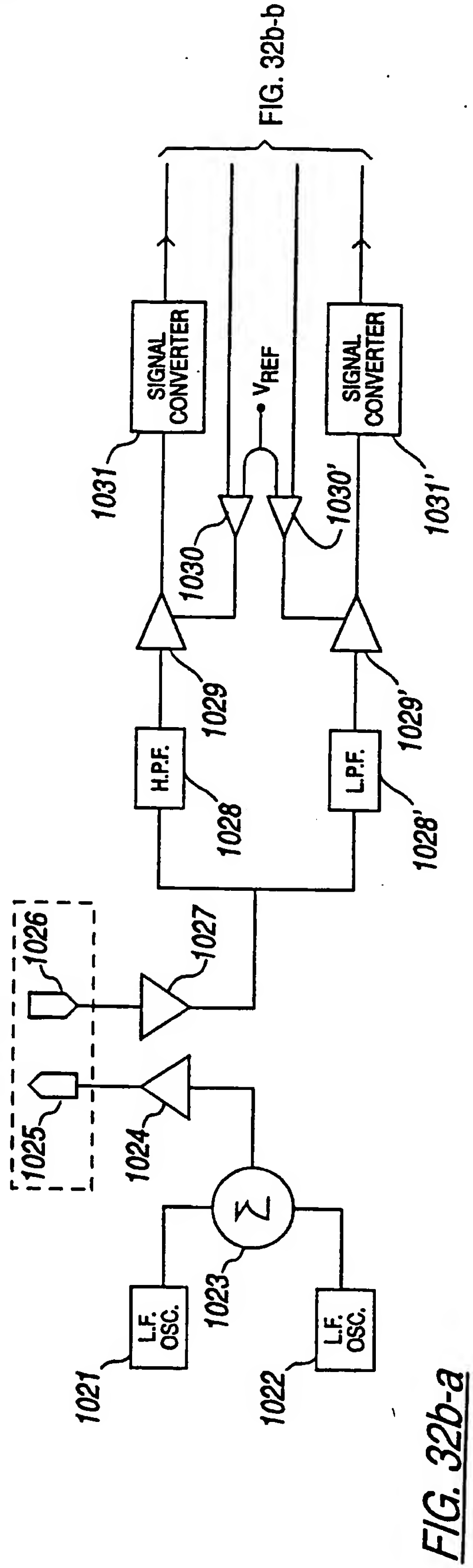


FIG. 32b-a

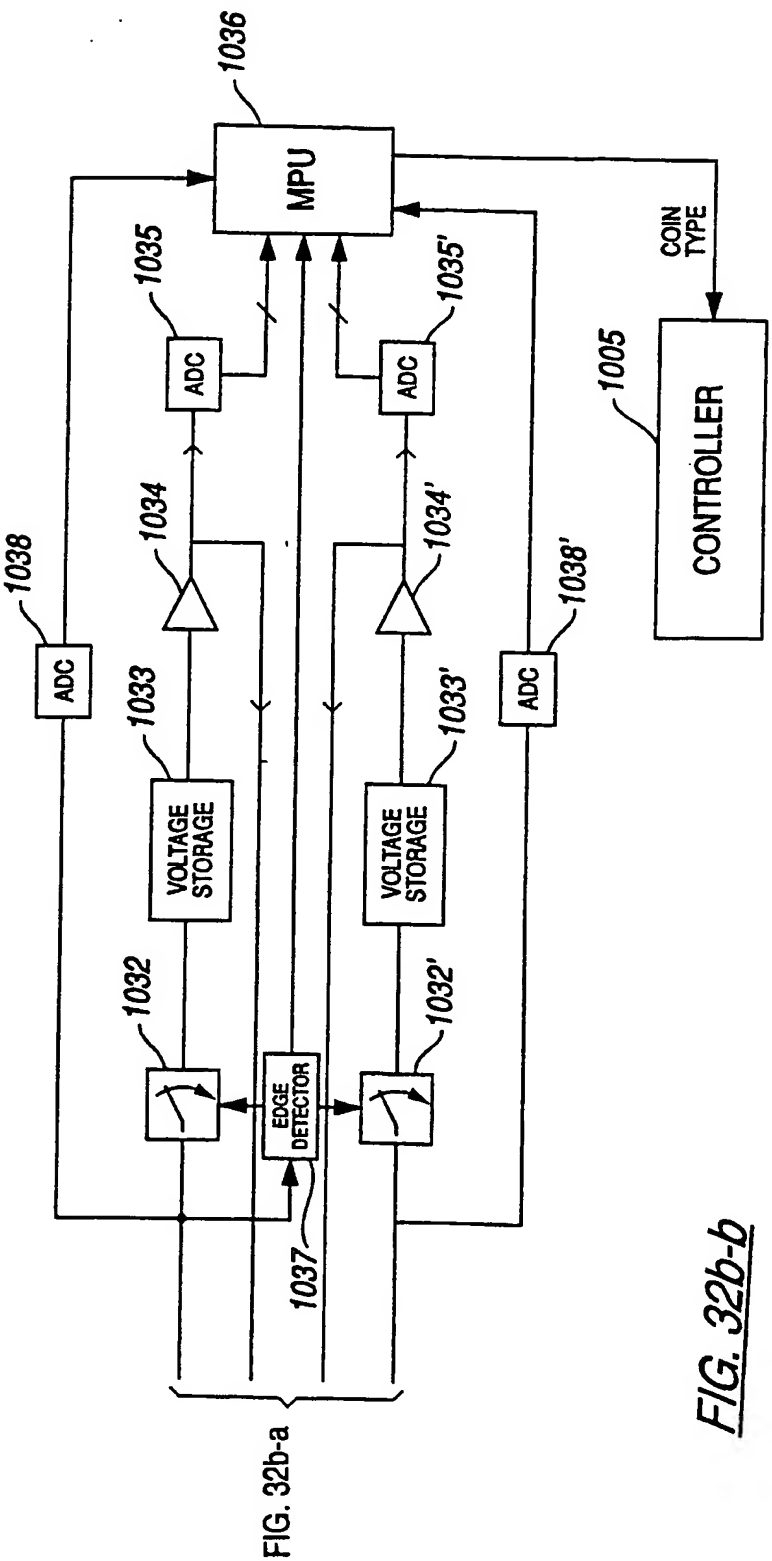

MPU
1036
COIN TYPE
CONTROLLER
1005
ADC
1035
ADC
1035'
1034
1034'
ADC
1038
ADC
1038'
VOLTAGE STORAGE
1033
VOLTAGE STORAGE
1033'
1032
1032'
EDGE DETECTOR
1037
FIG. 32b-a

FIG. 32b-b

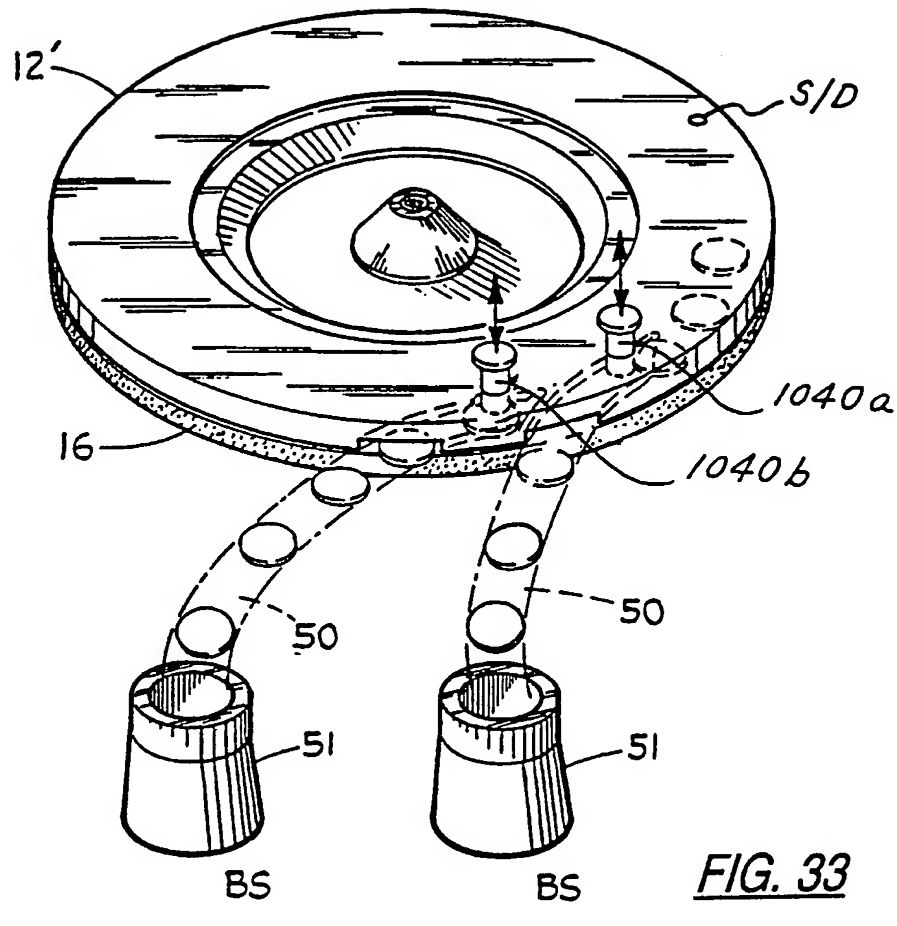


FIG. 33

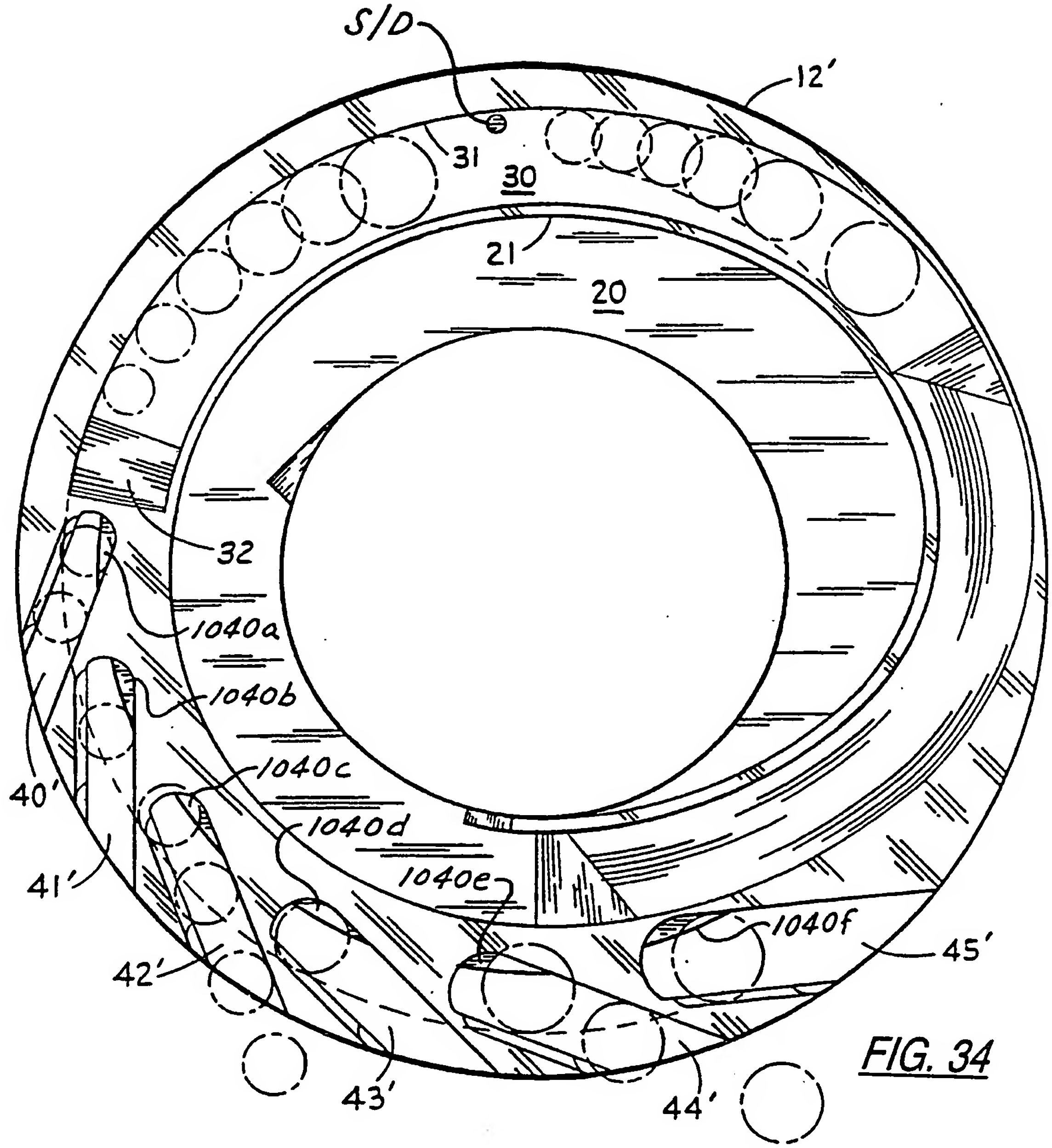

S/D
12'
31
30
21
20
32
1040a
1040b
1040c
1040d
1040e
1040f
40'
41'
42'
43'
44'
45'

FIG. 34

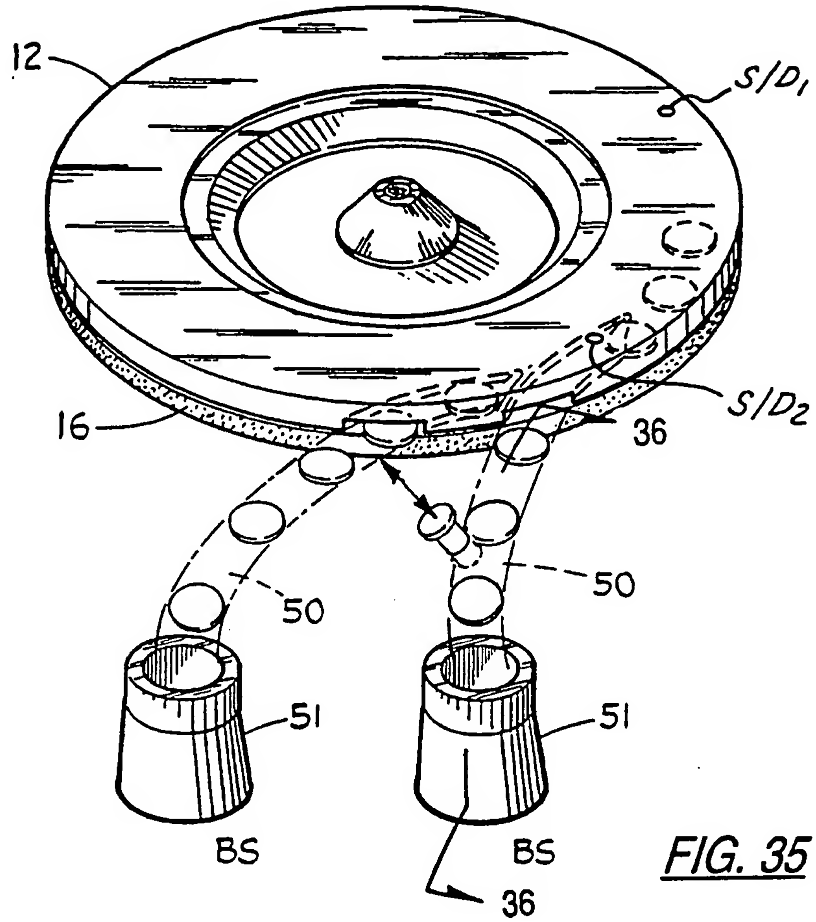

12
S/D1
S/D2
16
36
50
50
51
51
BS
BS
36

FIG. 35

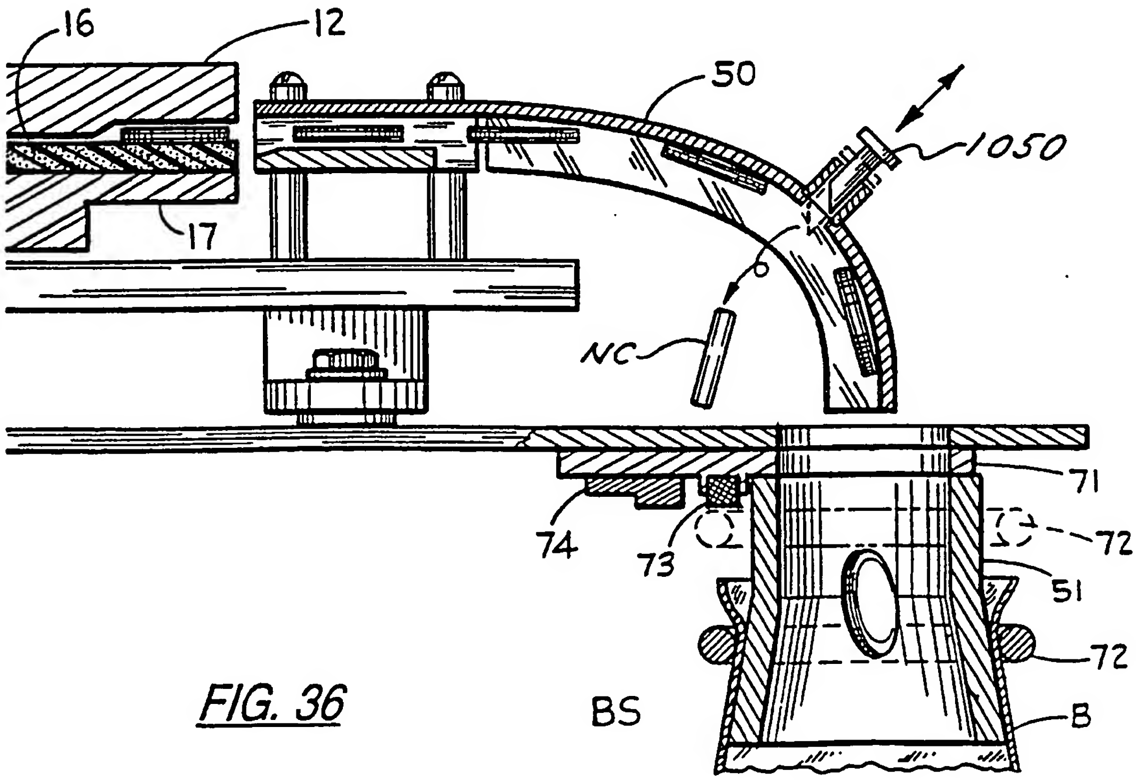

16
12
50
1050
17
NC
71
74
73
72
51
72
BS
B

FIG. 36

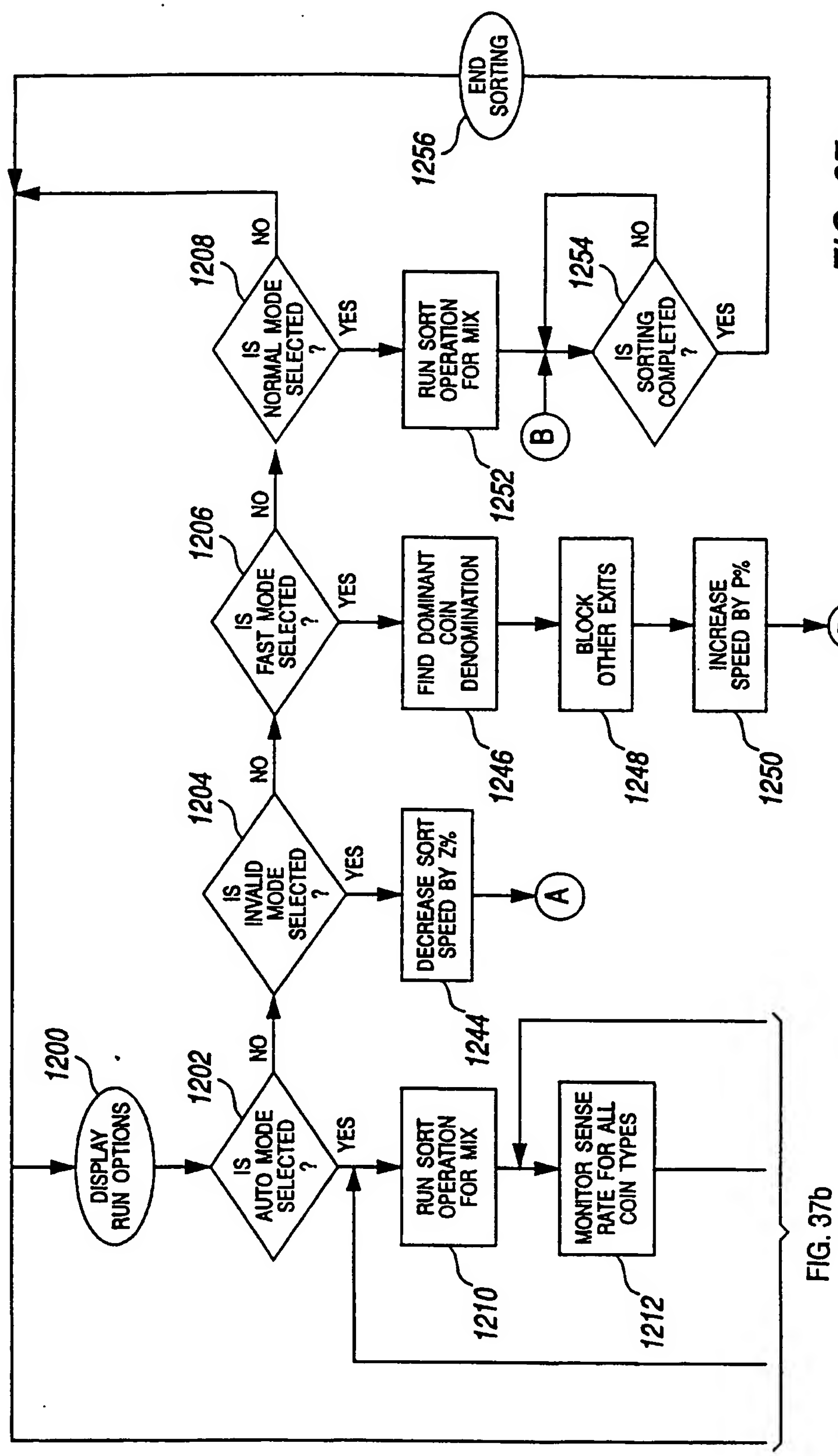

DISPLAY RUN OPTIONS
1200
IS AUTO MODE SELECTED ?
1202
YES
NO
RUN SORT OPERATION FOR MIX
1210
MONITOR SENSE RATE FOR ALL COIN TYPES
1212
IS INVALID MODE SELECTED ?
1204
DECREASE SORT SPEED BY Z%
1244
A
IS FAST MODE SELECTED ?
1206
FIND DOMINANT COIN DENOMINATION
1246
BLOCK OTHER EXITS
1248
INCREASE SPEED BY P%
1250
B
IS NORMAL MODE SELECTED ?
1208
RUN SORT OPERATION FOR MIX
1252
IS SORTING COMPLETED ?
1254
END SORTING
1256
FIG. 37b

FIG. 37a

FIG. 37a

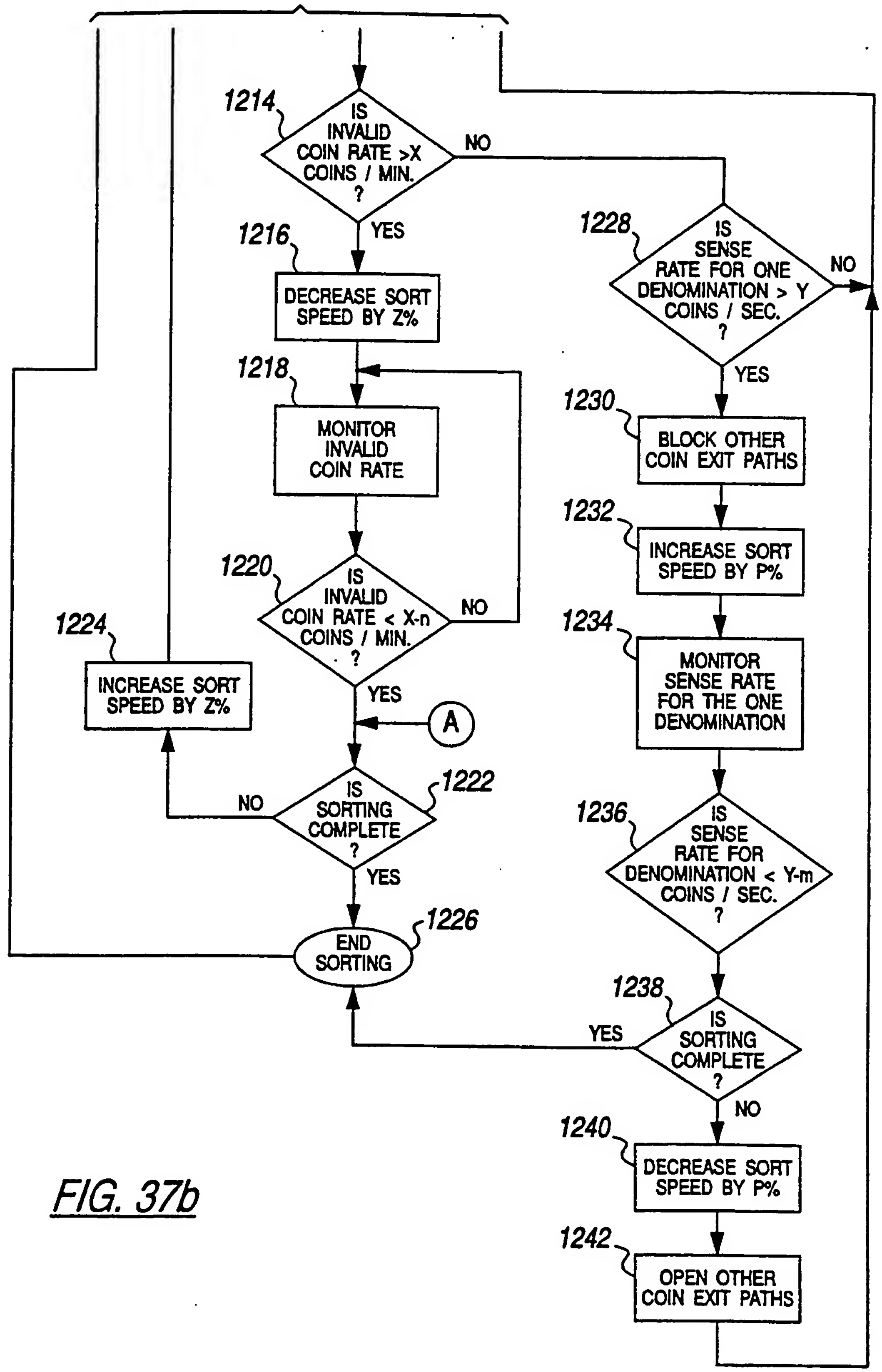


FIG. 37b

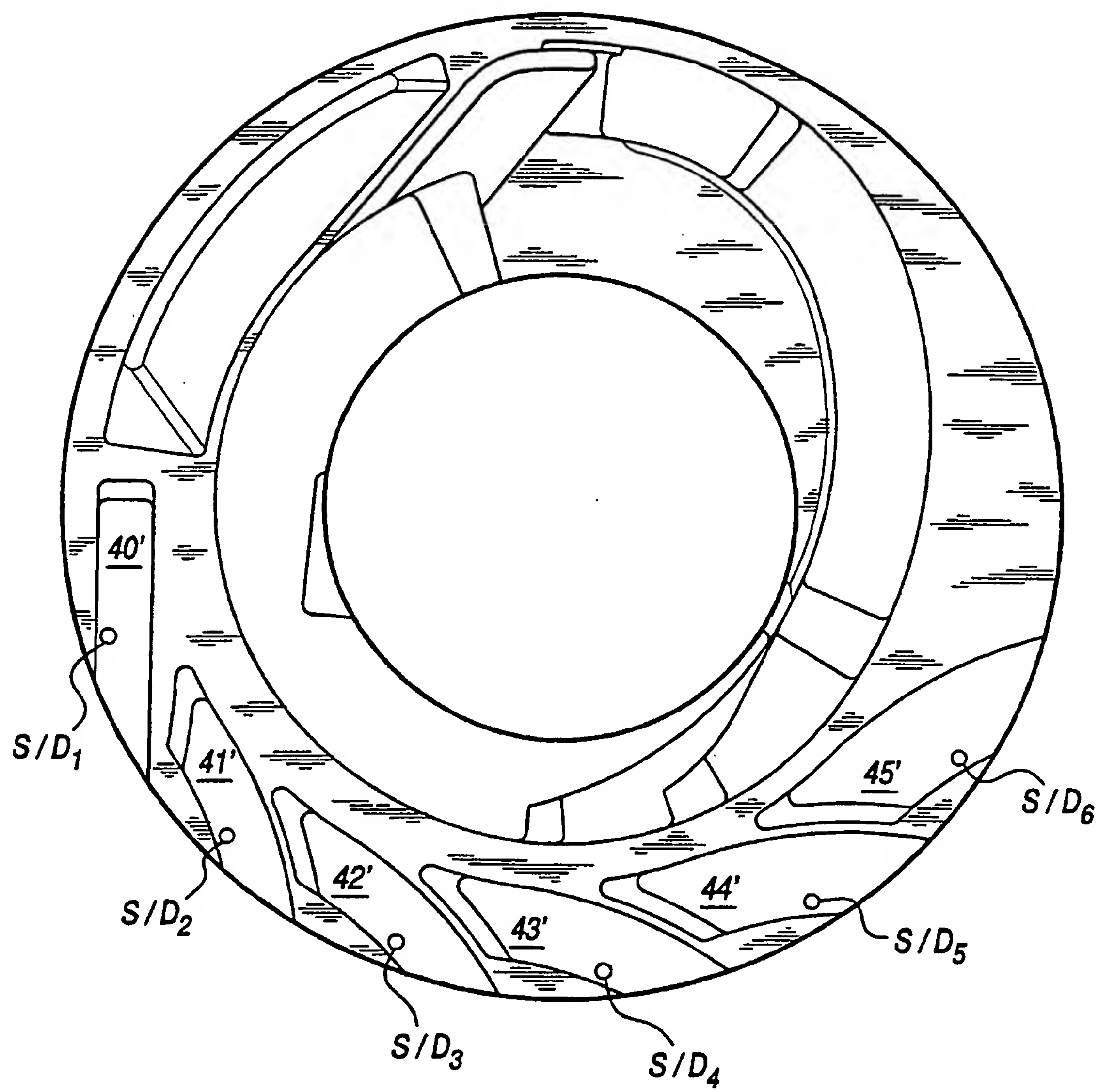


FIG. 38

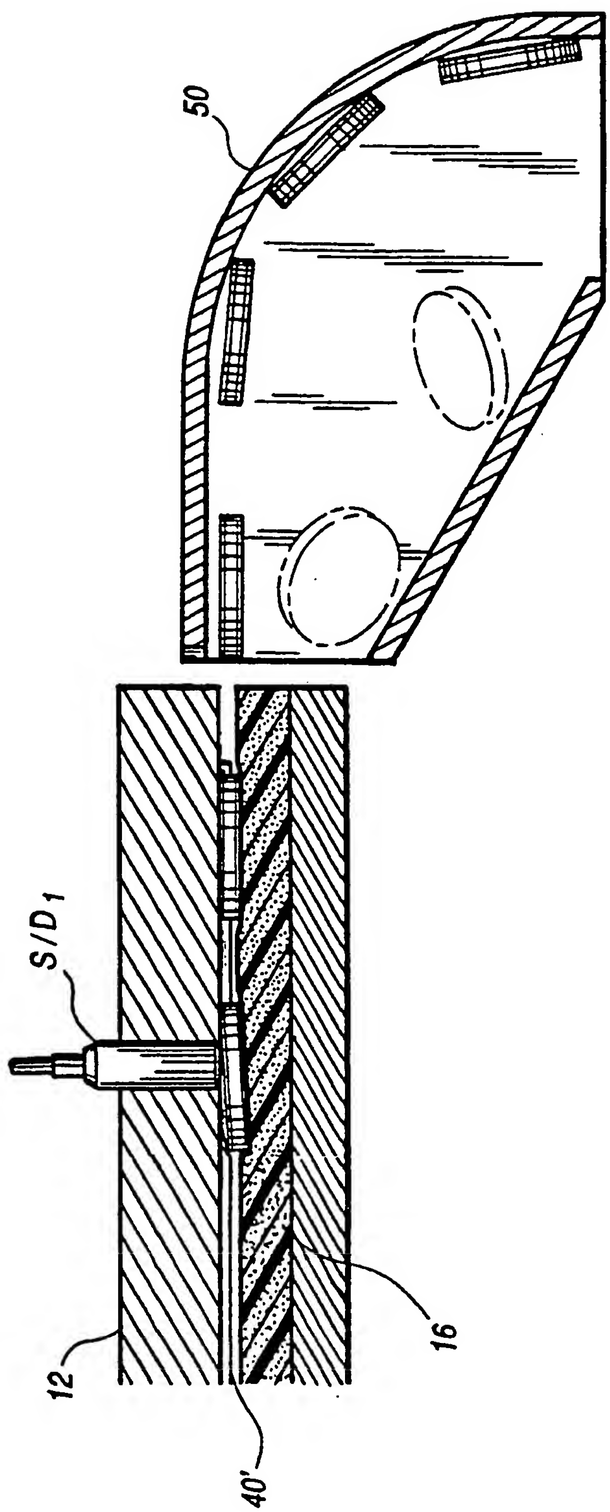


FIG. 39

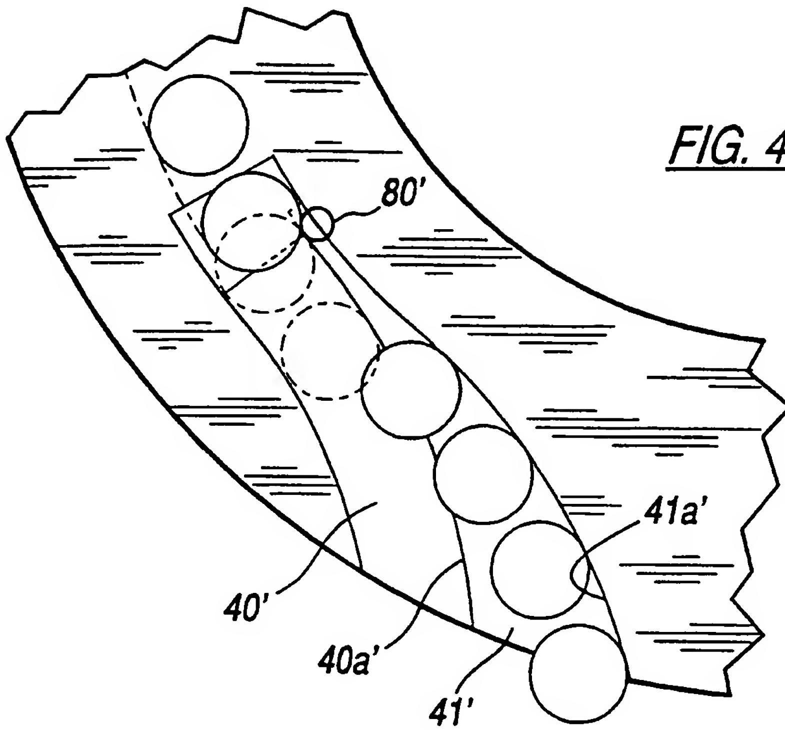


FIG. 40a

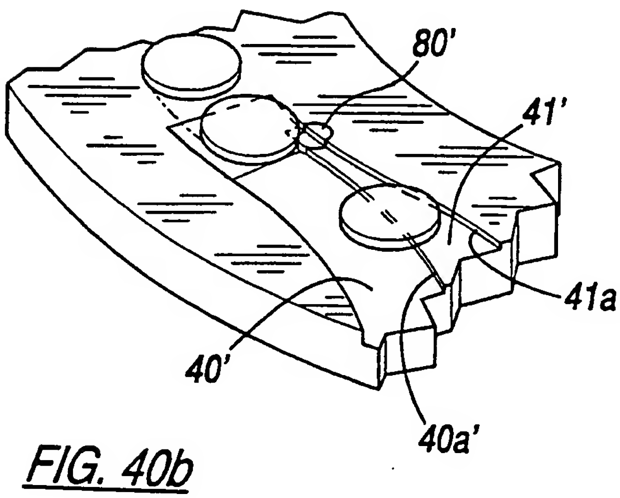


FIG. 40b

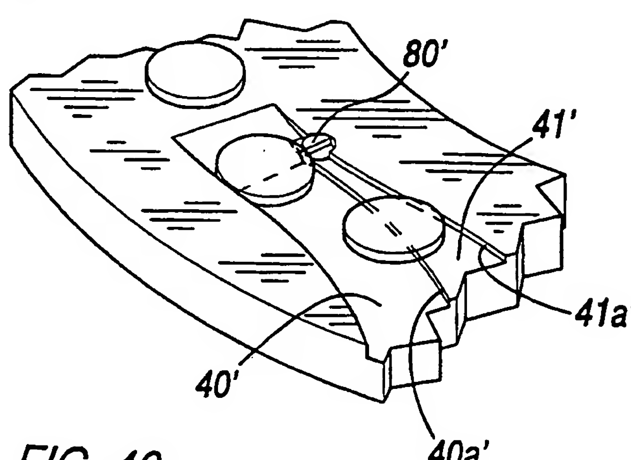


FIG. 40c

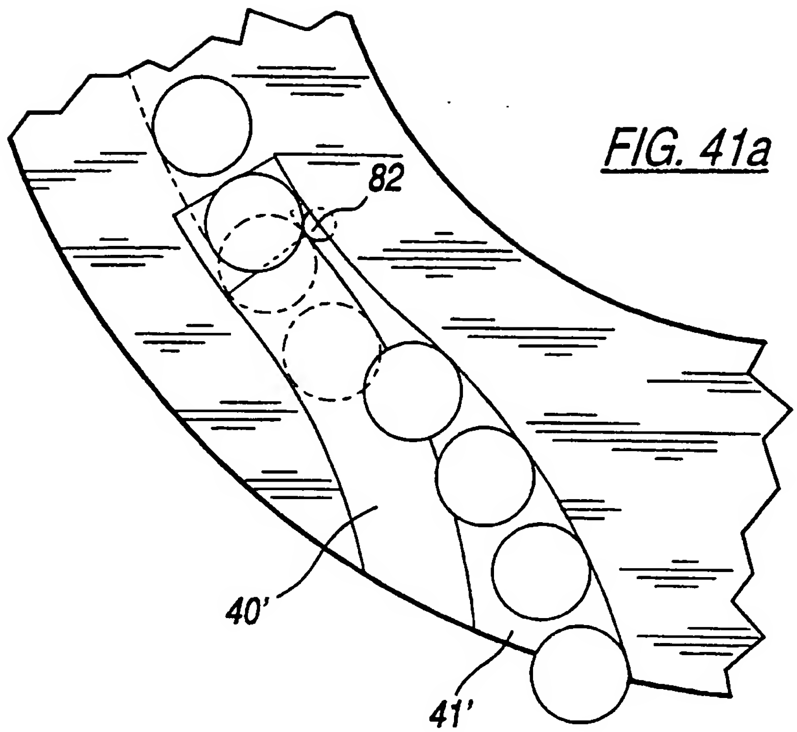


FIG. 41a

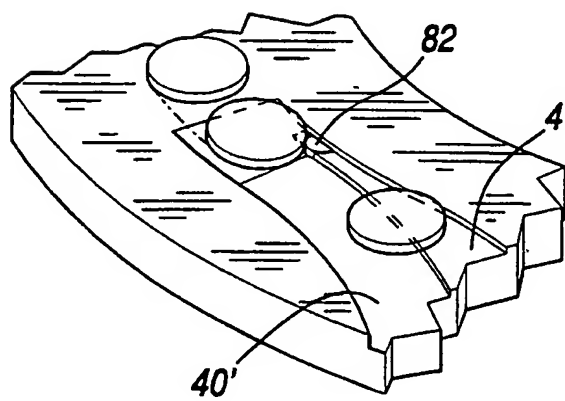


FIG. 41b

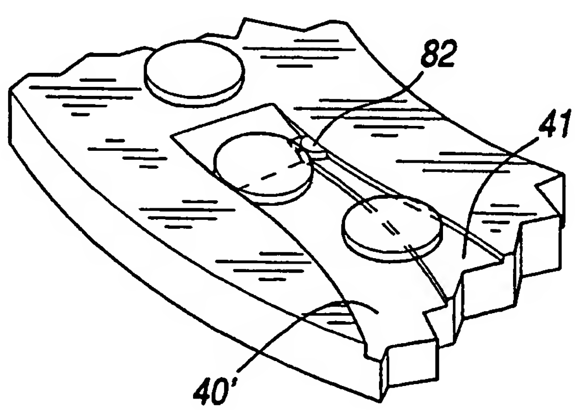


FIG. 41c

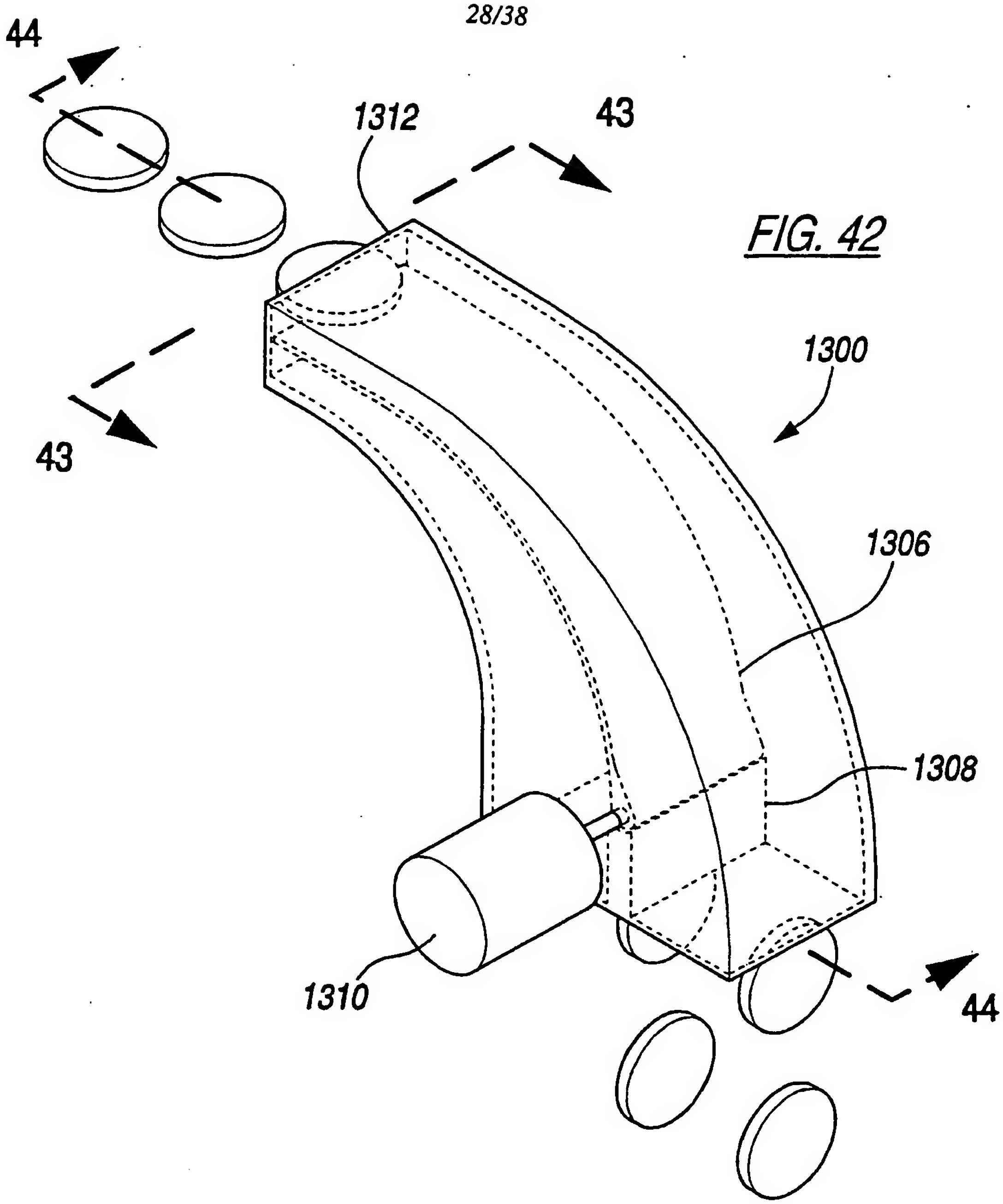


FIG. 42

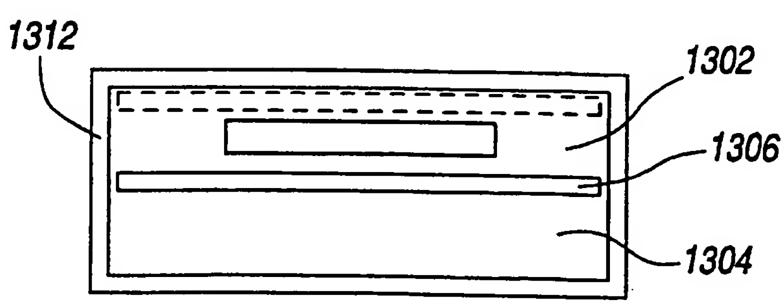


FIG. 43

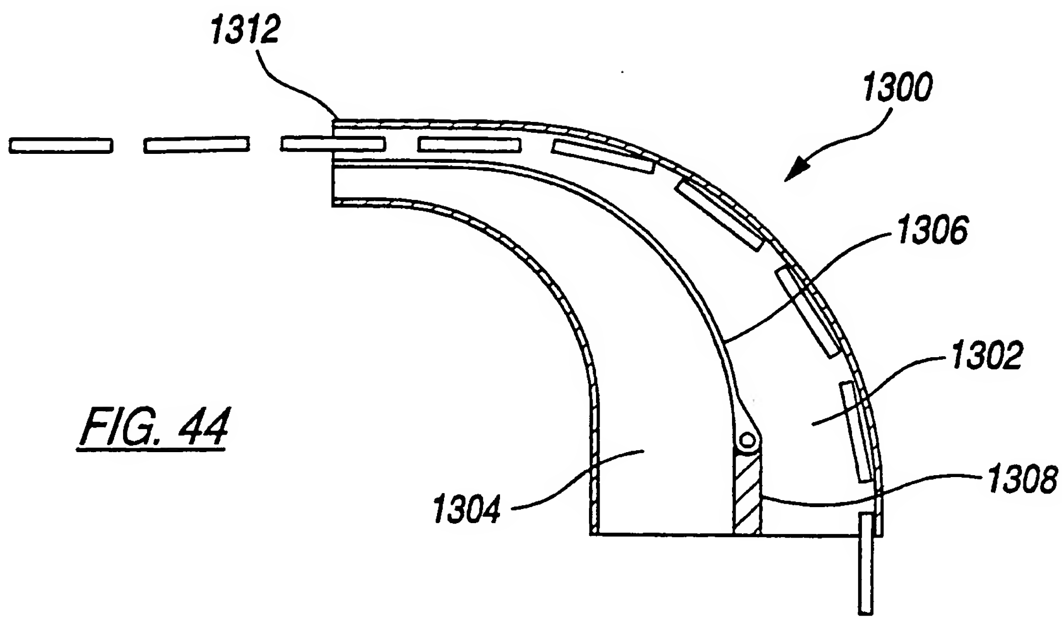


FIG. 44

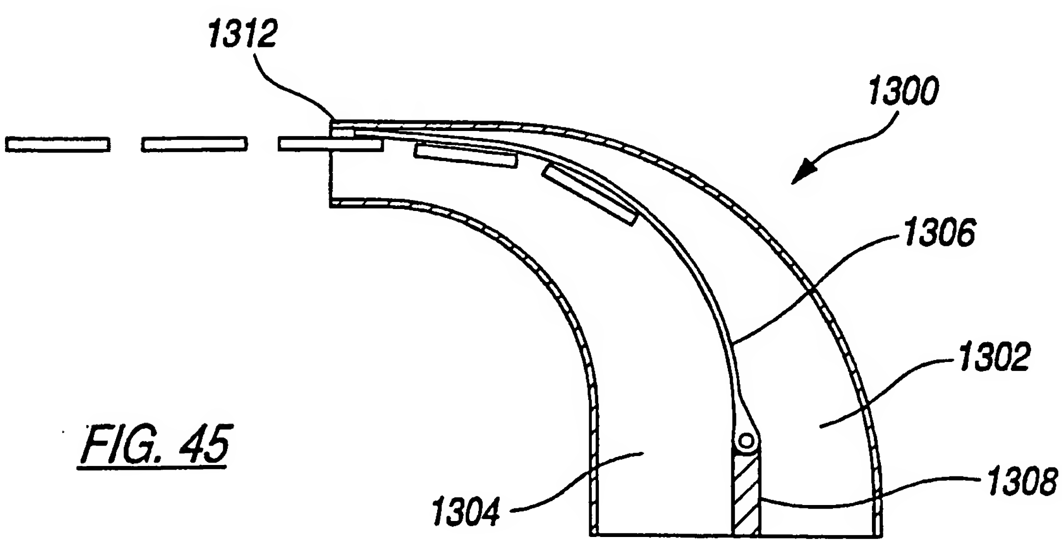


FIG. 45

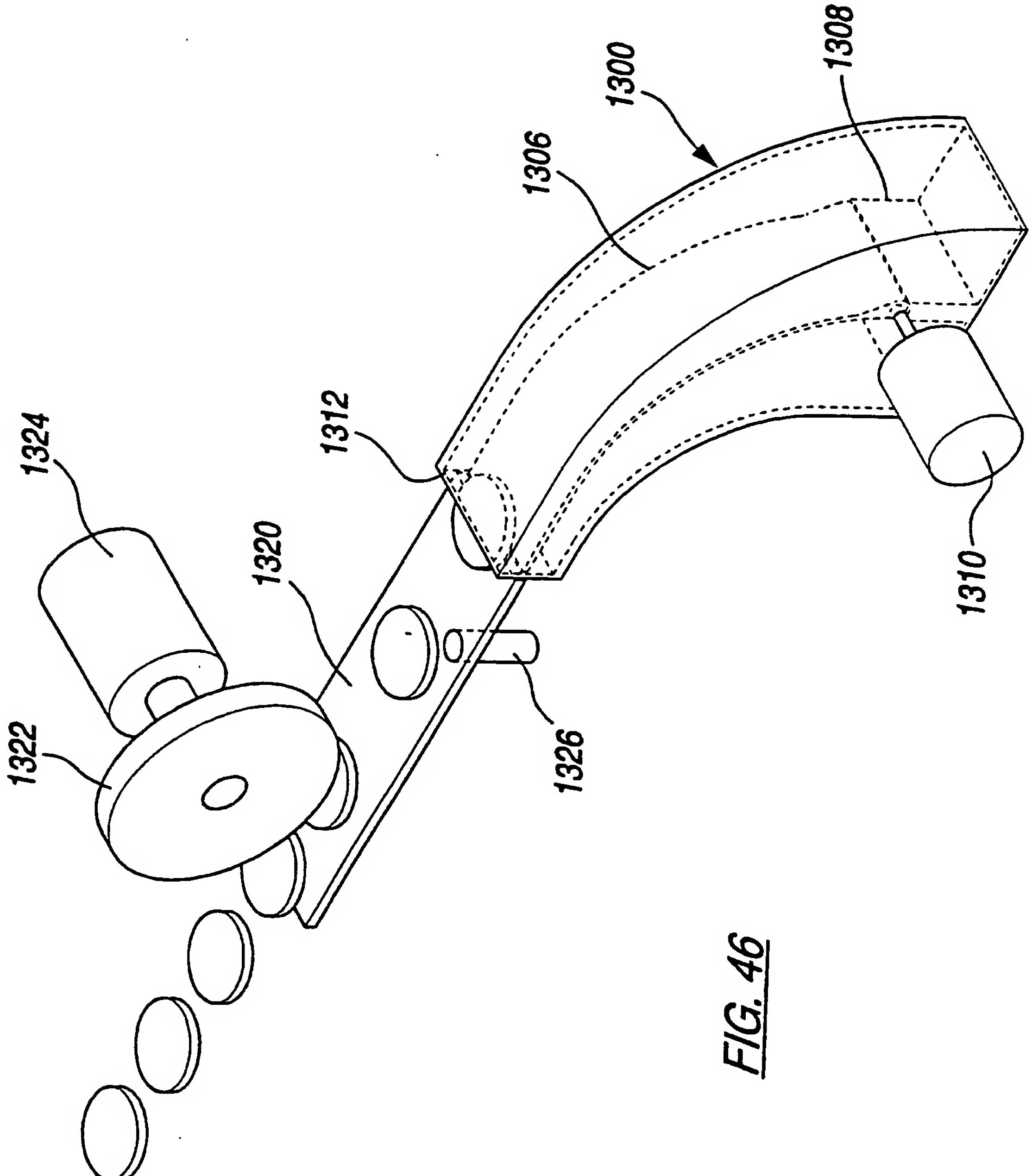


FIG. 46

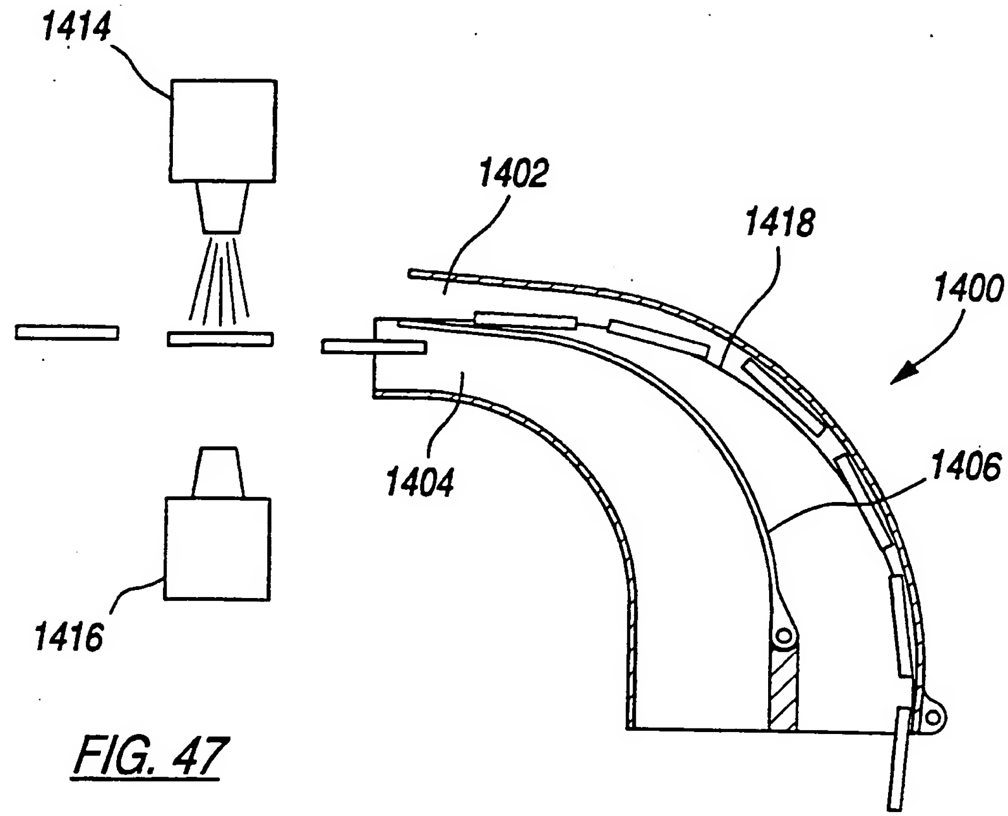

1414
1402
1418
1400
1404
1406
1416

FIG. 47

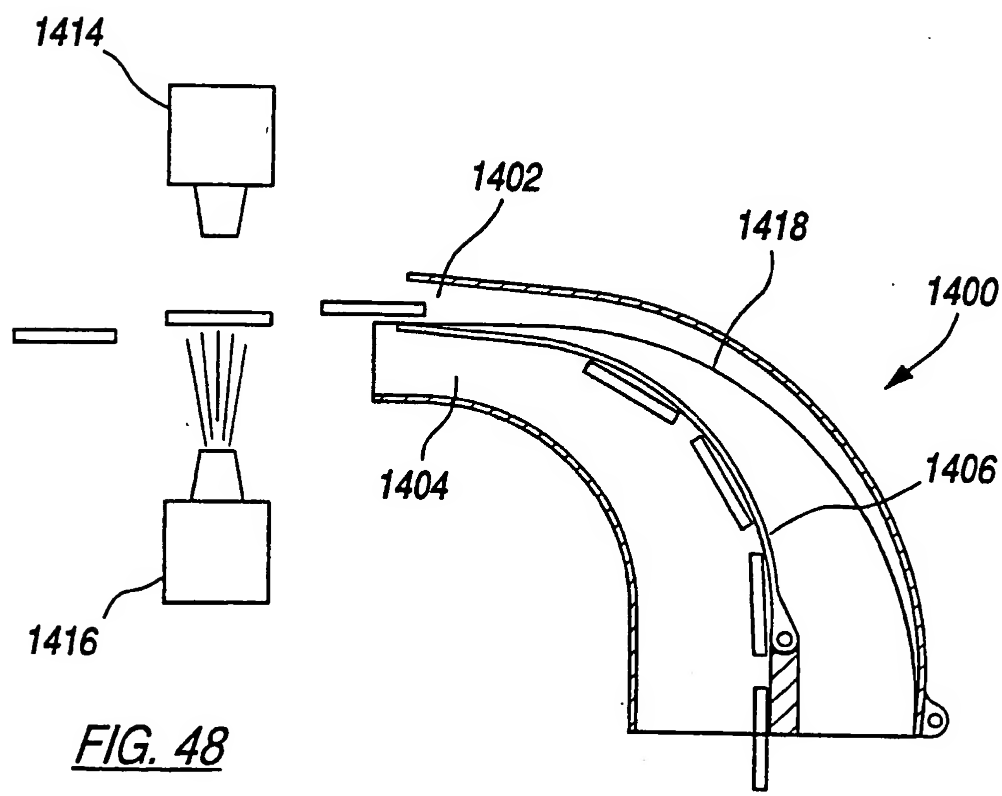

1414
1402
1418
1400
1404
1406
1416

FIG. 48

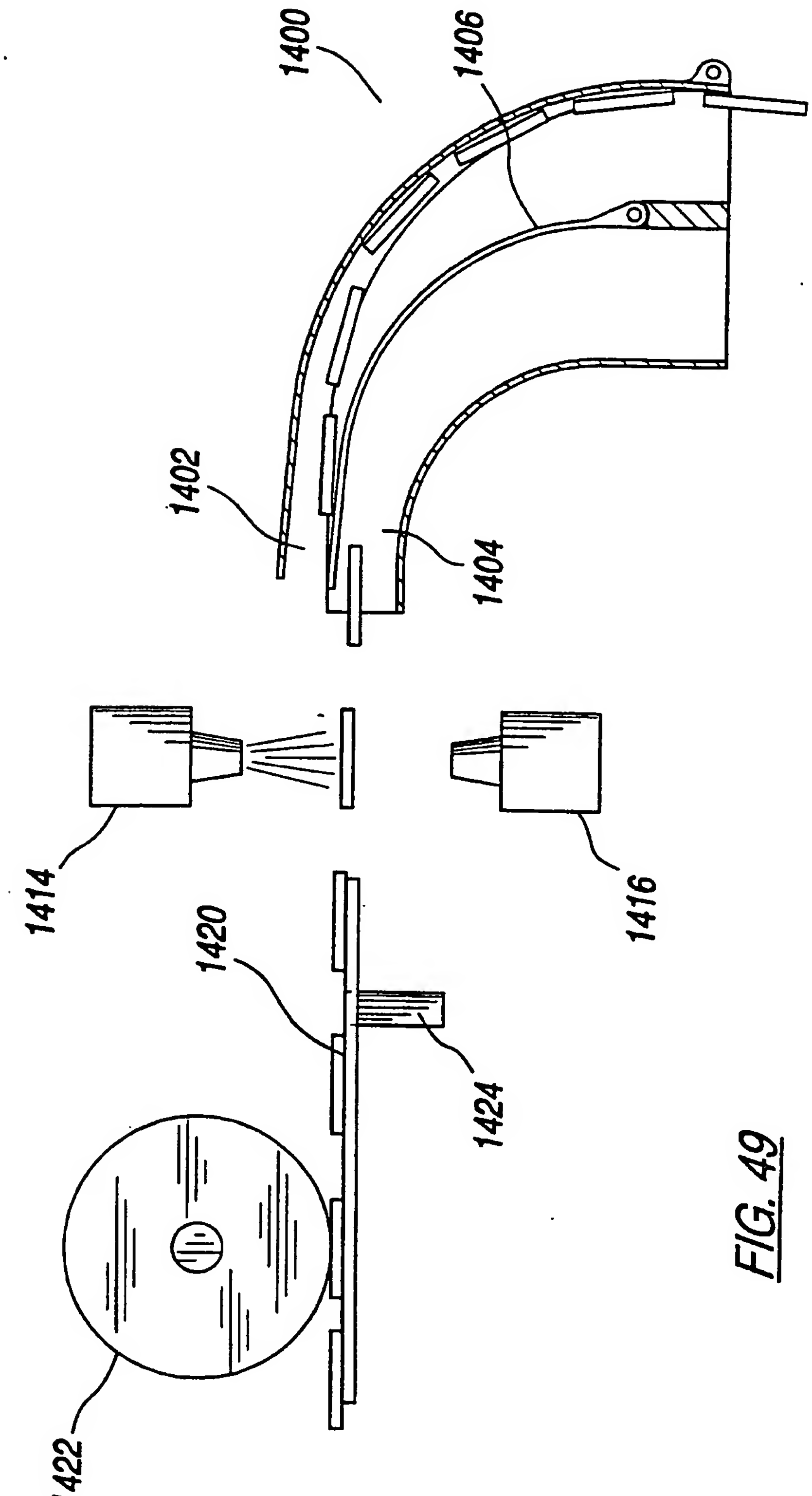


FIG. 49

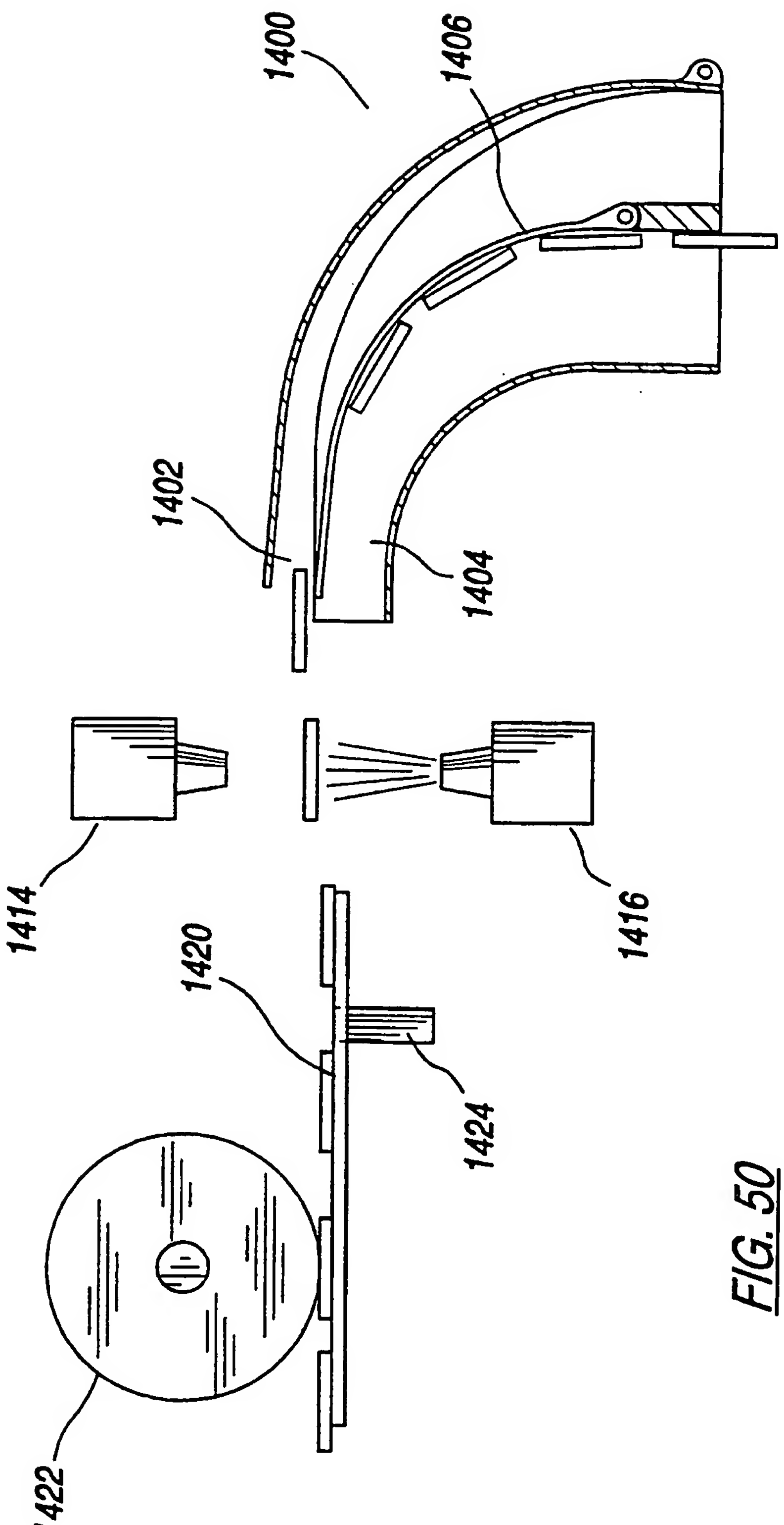


FIG. 50

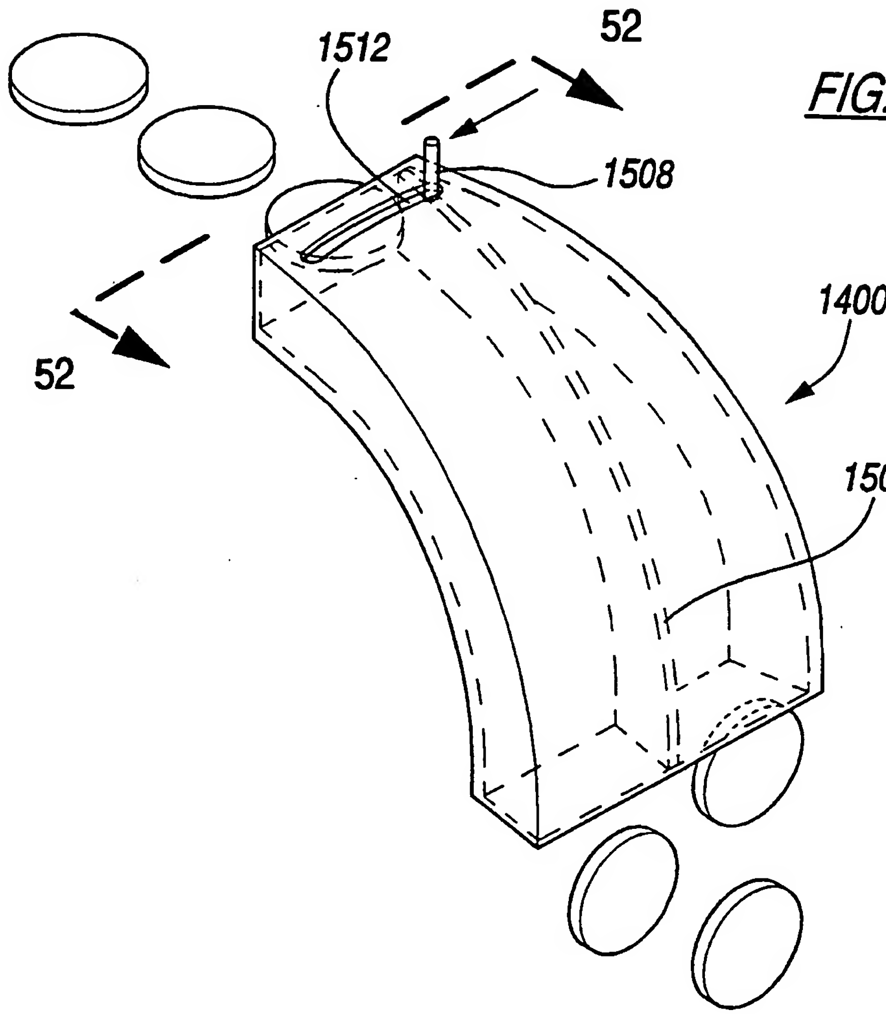


FIG. 51

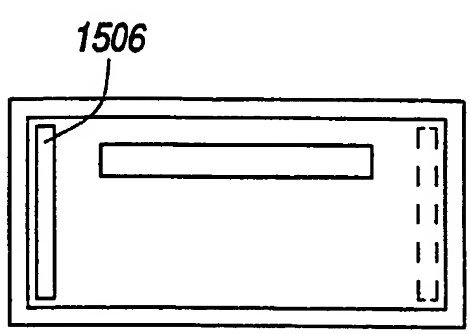


FIG. 52

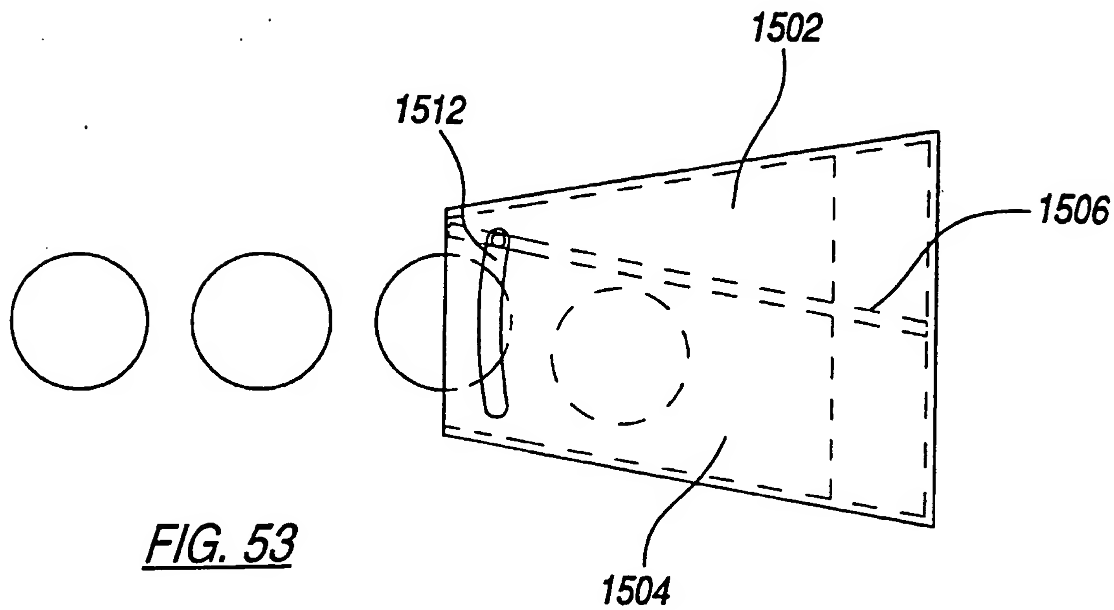


FIG. 53

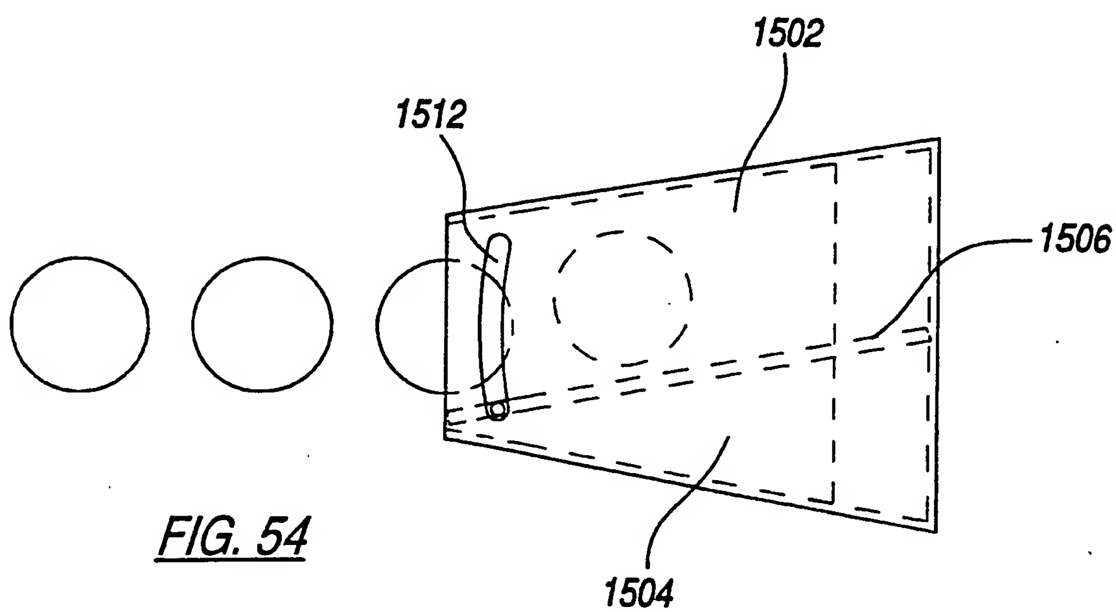


FIG. 54

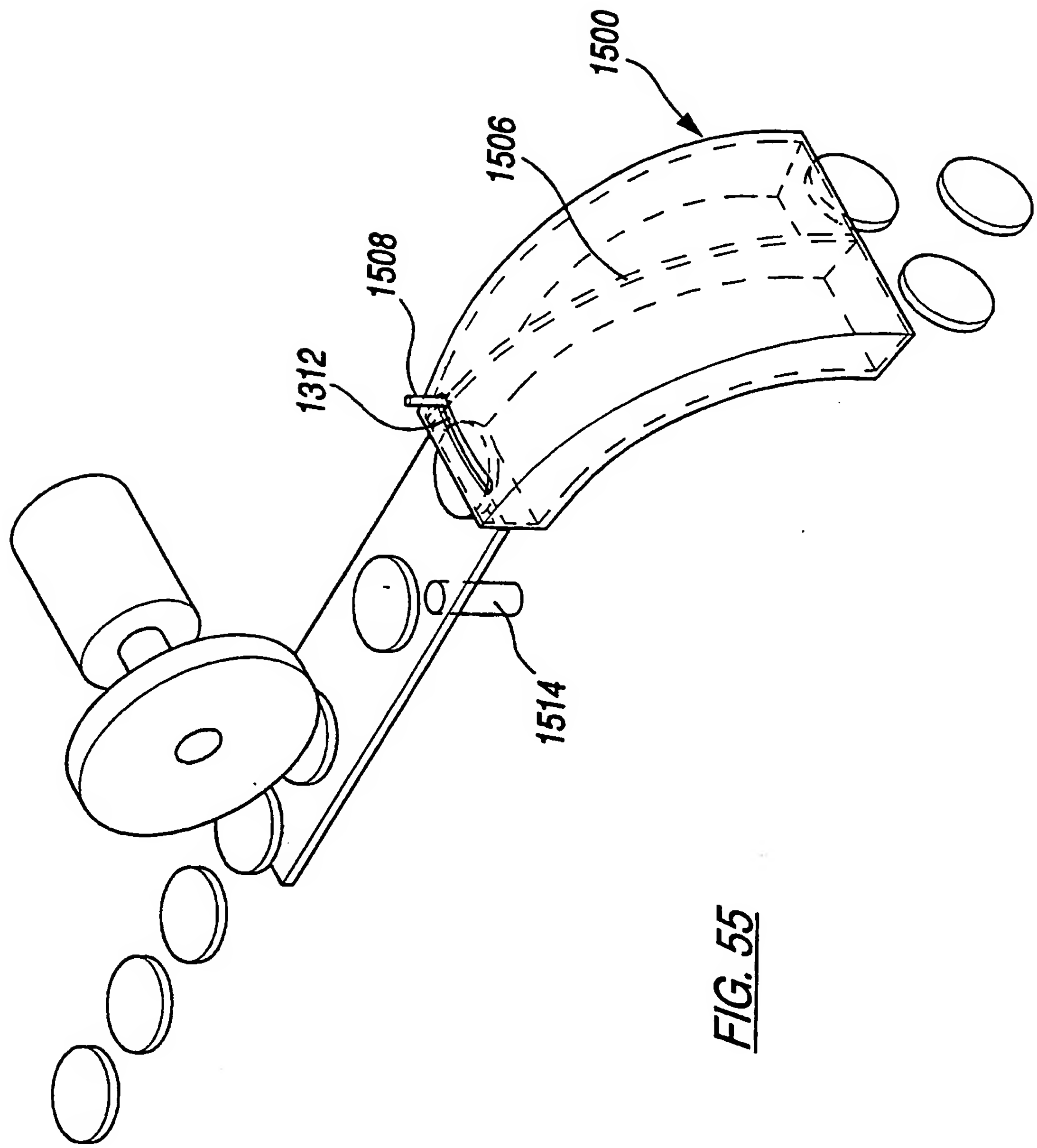


FIG. 55

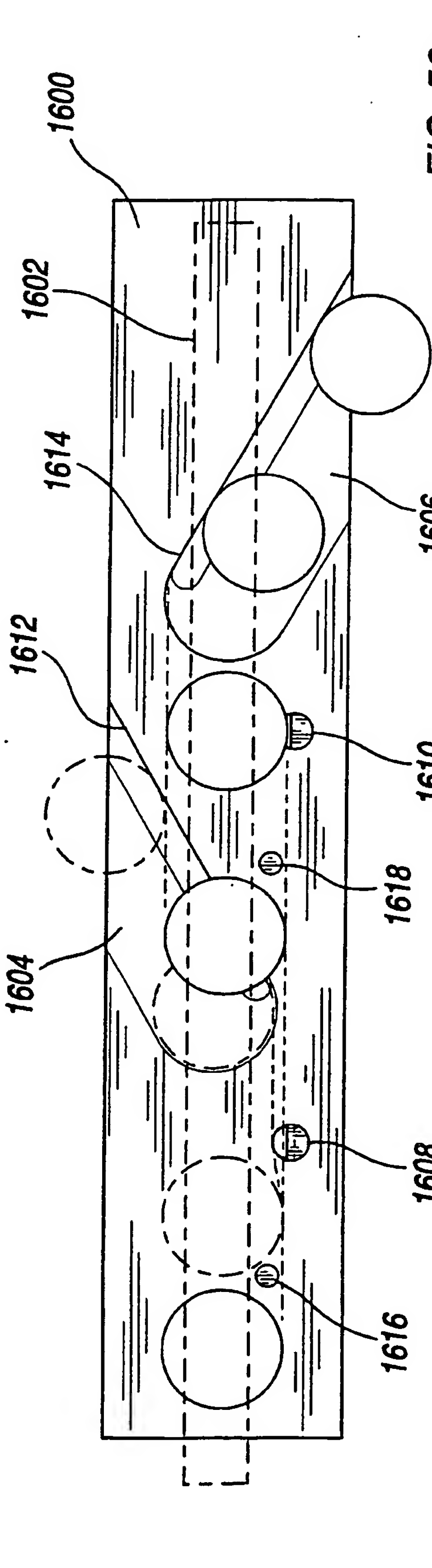


FIG. 56a

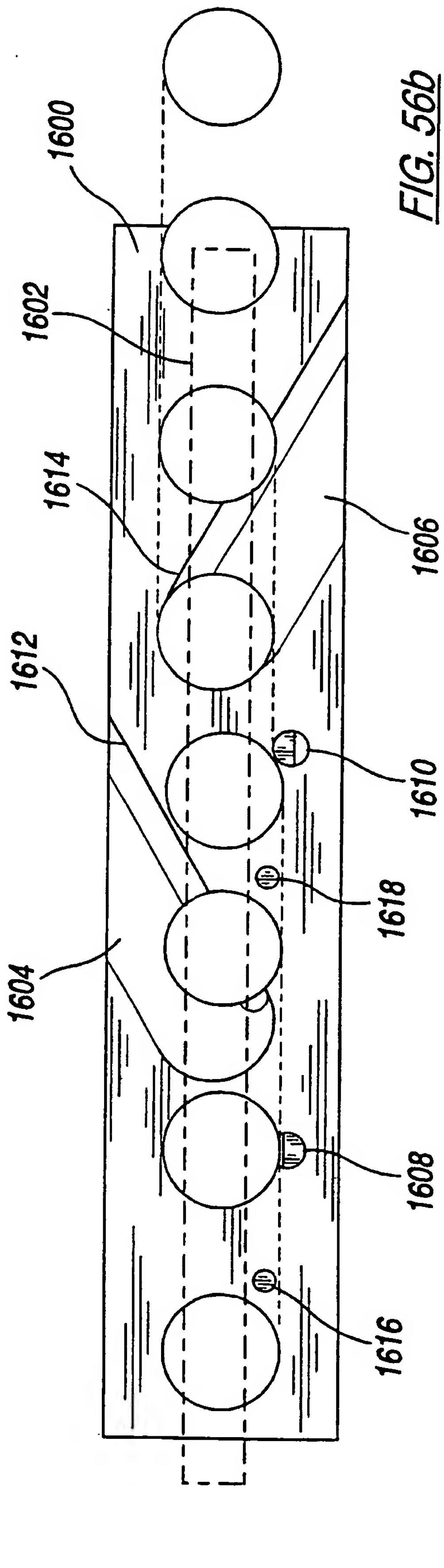


FIG. 56b

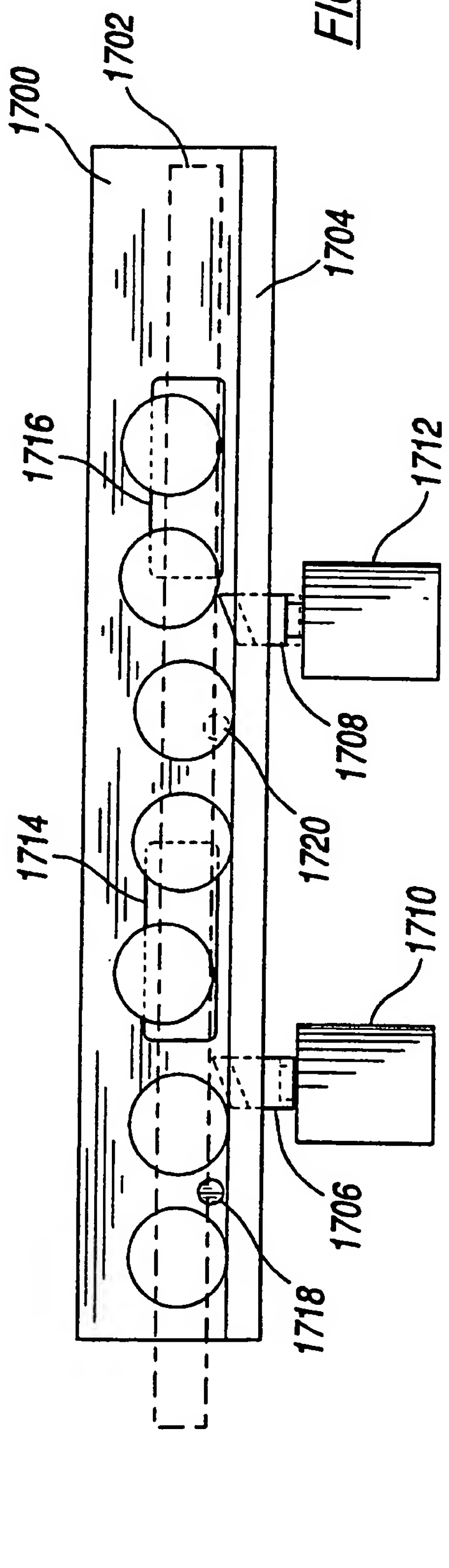


FIG. 57a

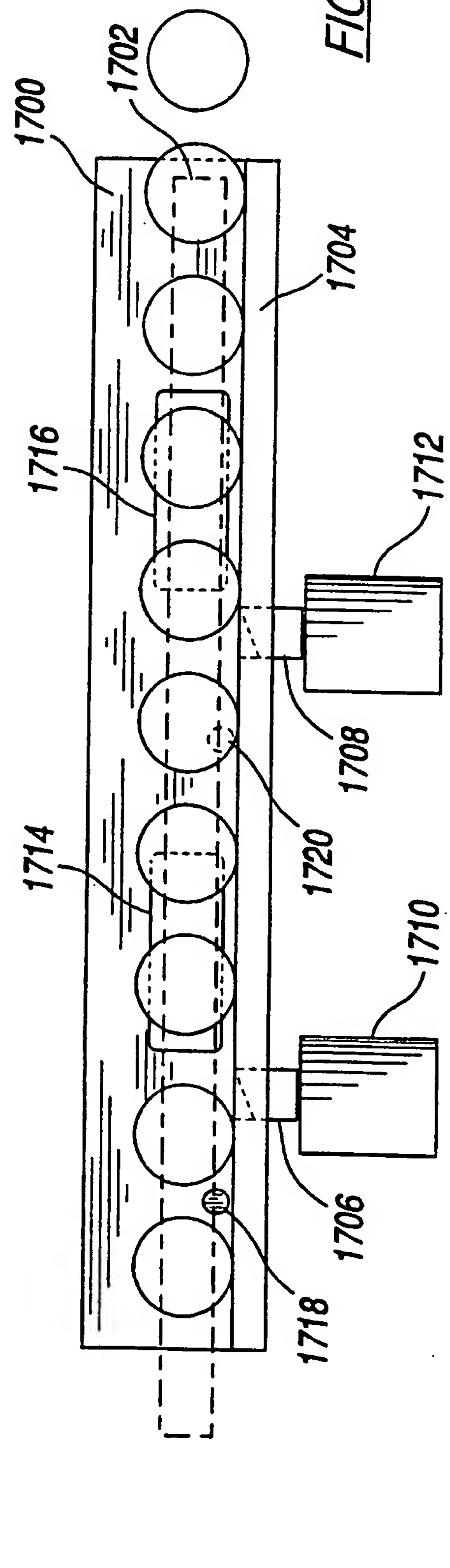


FIG. 57b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/02216

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :G07D 3/16
US CL :194/317
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S : 194/317, 318, 319; 453/003, 004, 006, 007, 010, 011, 032; 209/639, 644

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US, A, 4,620,559 (CHILDERS ET AL.) 04 November 1986. See col. 10, lines 3-22.	1, 3, 26, 27, 28, 38, 39, 49 — 2, 4-6, 8-12, 16, 18, 21-25, 29, 30-37, 47, 48
X — Y	US, A, 4,111,216 (BRISEBARRE) 05 September 1978. See col. 3, lines 15-37.	53 — 47, 48
Y	US, A, 4,850,469 (HAYASHI ET AL.) 25 July 1989. See col. 3, lines 21-31.	2

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 MAY 1995	01 JUN 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer F. J. Bartuska
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1113

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,172,462 (UCHIDA ET AL.) 30 October 1979. See col. 6, lines 12-20.	4, 5, 29
Y	US, A, 3,788,440 (PROPICE ET AL.) 29 January 1974. See col. 2, line 54 to col. 3, line 48.	20, 21, 32, 33
Y	US, A, 4,681,204 (ZIMMERMANN) 21 July 1987. See col. 8, lines 9-67.	22, 23, 34, 35
Y	US, A, 4,681,128 (RISTVEDT ET AL.) 21 July 1987. See col. 3, lines 8-52.	1, 3, 24-28, 36-39
Y	US, A, 5,090,576 (MENTEN) 25 February 1992. See col. 3, lines 37 to 68.	6
Y	US, A, 4,881,918 (GOH et al.) 21 November 1989. See col. 6, lines 53 to Col. 7, line 13.	8, 11, 12, 16, 18, 30, 31
Y	US, A, 5,230,653 (SHINOZAKI ET AL.) 27 July 1993. See col. 6, line 42 to Col. 7, line 30.	8, 9, 10, 13, 14, 15, 41
X — Y	US, A, 5,011,455 (RASMUSSEN) 30 April 1991. See col. 8, line 30 to col. 9, line 5.	40, 42-46 — 41
Y	US, A, 4,753,624 (ADAMS et al.) 28 June 1988. See col. 6, line 27 to col. 7, line 2.	52
Y	US, A, 3,795,252 (BLACK) 05 March 1974. See col. 4, lines 7-41.	52